**2.1** Determine the current and power dissipated in the resistor in Fig. P2.1.


**Figure P2.1**

**SOLUTION:**

$$I = \frac{9}{12} = \frac{3}{4}\text{A}$$

$$P_{12\Omega} = I^2 R = \left(\frac{3}{4}\right)^2 (12)$$

$$P_{12\Omega} = 6.75 \text{ W}$$

**2.2** Determine the current and power dissipated in the resistors in Fig. P2.2.

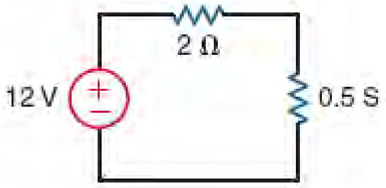



Figure P2.2

**SOLUTION:**

$$R_2 = \frac{1}{0.5} = 2\,\Omega$$

$$I = \frac{12}{2+2}$$

$$I = 3\text{A}$$

$$P_{R_1} = I^2 R_1 = (3)^2(2)$$

$$P_{R_1} = 18\text{ W}$$

$$P_{R_2} = I^2 R_2 = (3)^2(2)$$

$$P_{R_2} = 18\text{ W}$$

**2.3** Determine the voltage across the resistor in Fig. P2.3 and the power dissipated.


**Figure P2.3**

## SOLUTION:

$$V_R = I R$$

$$V_R = 2(12) = 24\ V$$

$$P_R = I^2 R = 2^2(12)$$

$$P_R = 48\ W$$

**2.4** Given the circuit in Fig. P2.4, find the voltage across each resistor and the power dissipated in each.


Figure P2.4

**SOLUTION:**

$$R_2 = \frac{1}{0.25} = 4\,\Omega$$

$$V_{R_1} = IR_1$$

$$V_{R_1} = 6(5) = 30\text{ V}$$

$$V_{R2} = IR_2 = 6(4) = 24\text{ V}$$

$$P_{R1} = \frac{V_{R_1}^2}{R_1} = \frac{(30)^2}{5}$$

$$P_{R1} = 180\text{ W}$$

$$P_{R_2} = \frac{V_{R_2}^2}{R_2} = \frac{(24)^2}{4}$$

$$P_{R2} = 144\text{ W}$$

**2.5** In the network in Fig. P2.5, the power absorbed by $R_x$ is 20 mW. Find $R_x$.

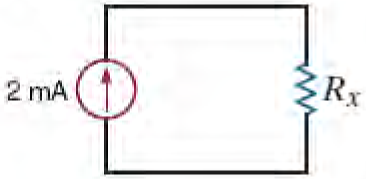



**Figure P2.5**

**SOLUTION:**

$$P_{Rx} = 20\,mW$$

$$P_{Rx} = I^2 R_x$$

$$R_x = \frac{P_{Rx}}{I^2} = \frac{20m}{(2m)^2} = \frac{20\times10^{-3}}{(2\times10^{-3})^2} = \frac{20\times10^{-3}}{4\times10^{-6}}$$

$$R_x = 5K\Omega$$

**2.6** In the network in Fig. P2.6, the power absorbed by $G_x$ is 20 mW. Find $G_x$.

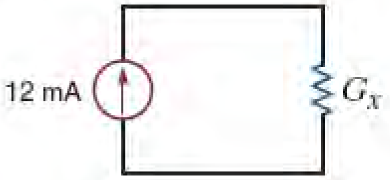



Figure P2.6

## SOLUTION:

$$P_{Gx} = 20\,mW$$

$$P_{Gx} = I^2\left(\frac{1}{Gx}\right)$$

$$Gx = \frac{I^2}{P_{Gx}} = \frac{(12m)^2}{20m} = \frac{144 \times 10^{-6}}{20 \times 10^{-3}}$$

$$Gx = 7.2\,mS$$

**2.7** A model for a standard two D-cell flashlight is shown in Fig. P2.7. Find the power dissipated in the lamp.

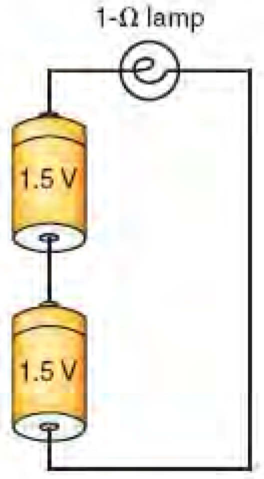



Figure P2.7

## SOLUTION:

$$I = \frac{V}{R}$$

$$I = \frac{1.5 + 1.5}{1}$$

$$I = 3A$$

$$P_{lamp} = I^2R = 3^2(1)$$

$$P_{lamp} = 9W$$

**2.8** An automobile uses two halogen headlights connected as shown in Fig. P2.8. Determine the power supplied by the battery if each headlight draws 3 A of current.

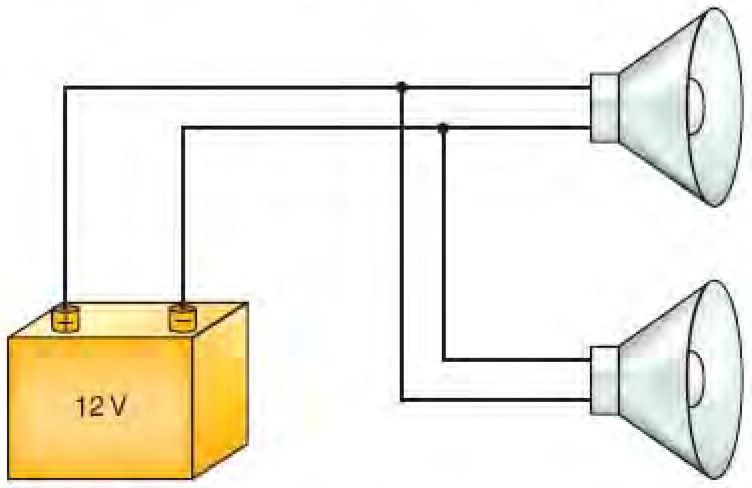



Figure P2.8

**SOLUTION:**

$$I_1 = I_2 = 3A$$

$$I = I_1 + I_2 = 6A$$

$$P_{12V} = VI = 12(6)$$

$$P_{12V} = 72\ W$$

**2.9** Many years ago a string of Christmas tree lights was manufactured in the form shown in Fig. P2.9a. Today the lights are manufactured as shown in Fig. P2.9b. Is there a good reason for this change?

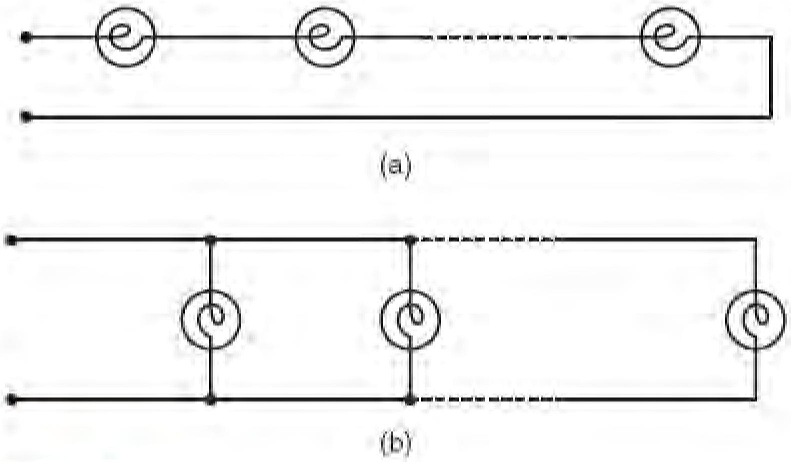



**Figure P2.9**

## SOLUTION:

When Christmas tree lights are connected in series as shown in Figure 2.9a, an open circuit bulb failure will cause all bulbs to turn off (no current flows.)
If the bulbs are connected in parallel as shown in Figure 2.9b, an open circuit bulb failure will only cause one bulb to turn off. The other bulbs will still function when connected in parallel.

**2.10** Find $I_1$ in the network in Fig. P2.10.

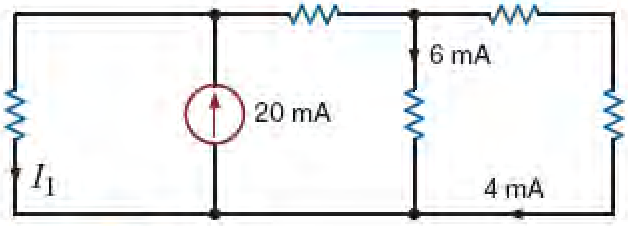



Figure P2.10

## SOLUTION:

KCL at node B: $I_2 = 6m + 4m$

$I_2 = 10mA$

KCL at node A: $I_1 + I_2 = 20m$

$I_1 = 20m - 10m$

$I_1 = 10mA$

**2.11** Find $I_1$ in the network in Fig. P2.11.

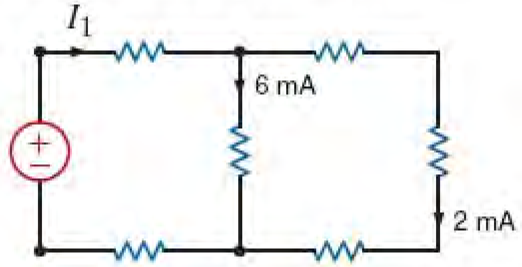



Figure P2.11

## SOLUTION:

KCL at node A: $I_1 = 6m + 2m$

$I_1 = 8mA$

**2.12** Find $I_1$ and $I_2$ in the network in Fig. P2.12.

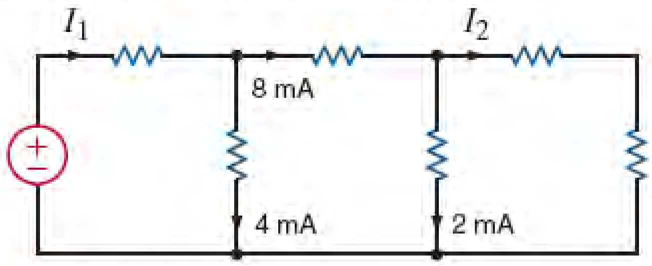
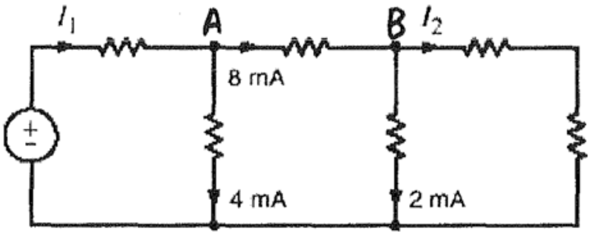



**Figure P2.12**

**SOLUTION:**




KCL at node A: $I_1 = 4m + 8m$

$I_1 = 12mA$

KCL at node B: $8m = 2m + I_2$

$I_2 = 6mA$

**2.13** Find $I_1$ in the circuit in Fig. P2.13.

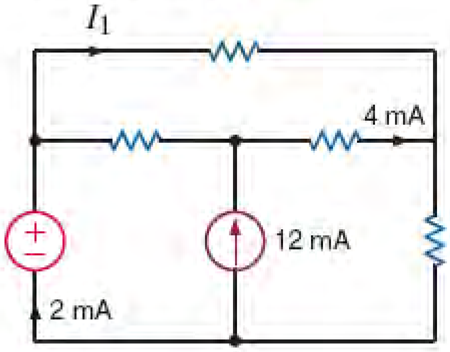
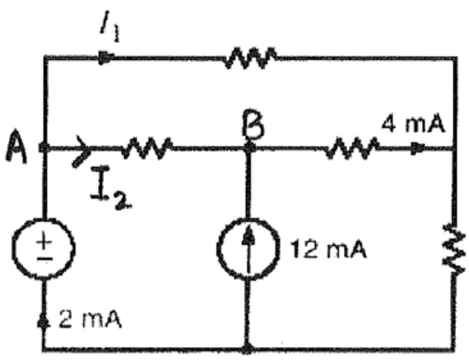



Figure P2.13

**SOLUTION:**




KCL at node B: $I_2 + 12m = 4m$

$I_2 = -8mA$

KCL at node A: $2m = I_1 + I_2$

$I_1 = 10mA$

**2.14** Find $I_x$ in the network in Fig. P2.14.

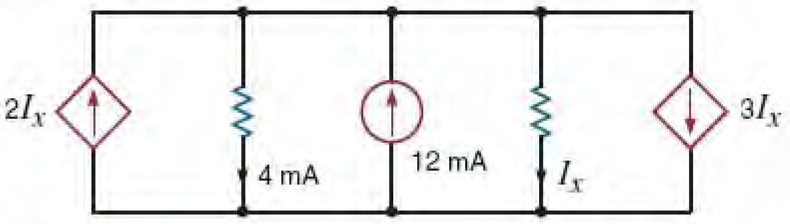



Figure P2.14

**SOLUTION:**

$$-2I_x + \frac{4}{K} - \frac{12}{K} + I_x + 3I_x = 0$$

$$2I_x = \frac{8}{K}$$

$$I_x = 4\text{mA}$$

**2.15** Determine $I_L$ in the circuit in Fig. P2.15.

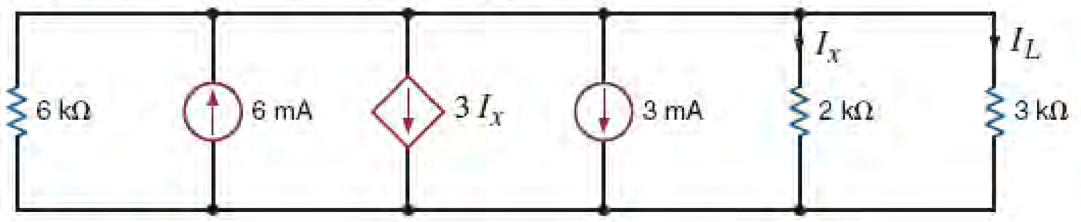



Figure P2.15

## SOLUTION:

$$6m = \frac{V}{6k} + 3I_x + 3m + I_x + I_L$$

$$\frac{V}{6K} + 4I_x + I_L = 3m$$

$$I_x = \frac{V}{2K} \quad \text{and} \quad I_L = \frac{V}{3K}$$

$$\frac{V}{6K} + 4\left(\frac{V}{2K}\right) + \frac{V}{3k} = 3m$$

$$V + 12V + 2V = 18$$

$$15V = 18$$

$$V = \frac{18}{15} V$$

$$I_L = \frac{18}{15(3k)}$$

$$I_L = 0.4mA$$

**2.16** Find $I_o$ and $I_1$ in the circuit in Fig. P2.16.

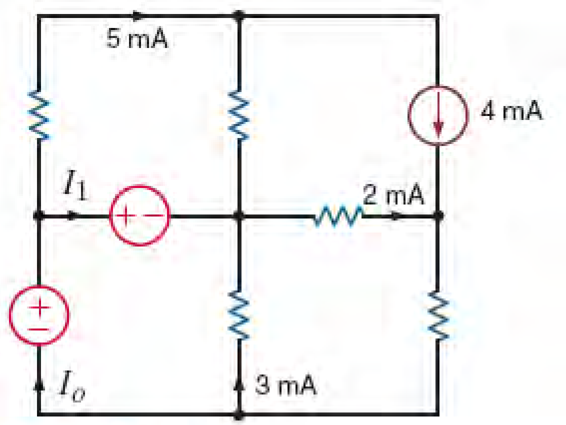
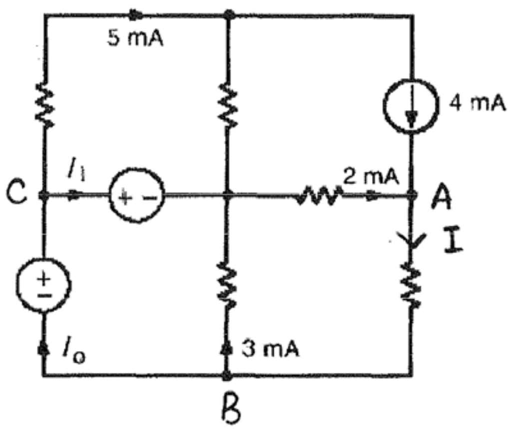



Figure P2.16

**SOLUTION:**




KCL at node A: $4m + 2m = I$

$I = 6mA$

KCL at node B: $I = 3m + I_0$

$I_0 = 6m - 3m$

$I_0 = 3mA$

KCL at node C: $I_0 = I_1 + 5m$

$I_1 = -2mA$

**2.17** Find $I_1$ in the network in Fig. P2.17.

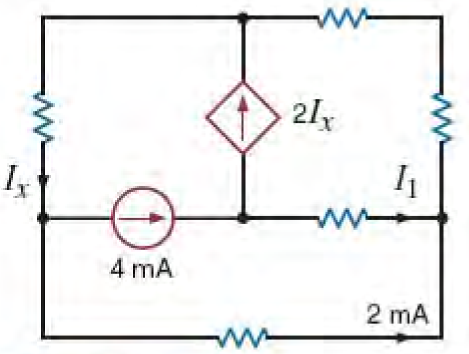



Figure P2.17

## SOLUTION:

$$I_x = 4\,mA + 2\,mA = 6\,mA$$

$$4\,mA = 2I_x + I_1$$

$$= 12\,mA + I_1$$

$$I_1 = -8\,mA$$

**2.18** Find $I_x$, $I_y$, and $I_z$ in the network in Fig. P2.18.

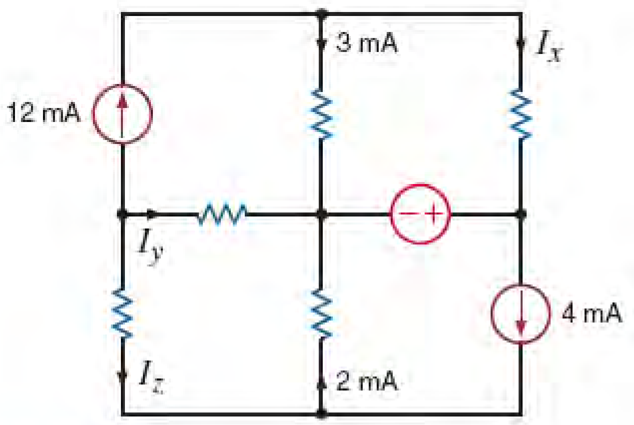



Figure P2.18

**SOLUTION:**

KCL at A: $12m = 3m + I_x$

$I_x = 9mA$

KCL at B: $I_z + 4m = 2m$

$I_z = -2mA$

KCL at C: $12m + I_y + I_z = 0$

$I_y = 2m - 12m$

$I_y = -10mA$

**2.19** Find $I_1$ in the circuit in Fig. P2.19.

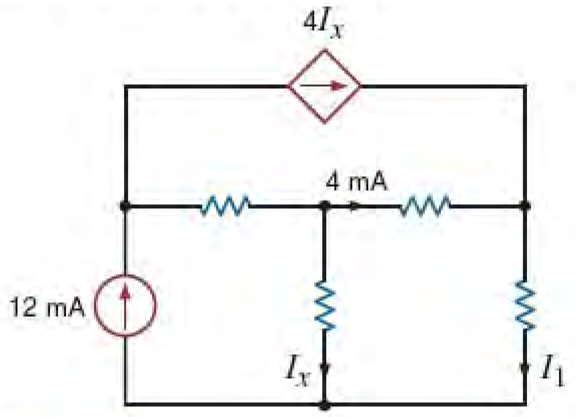



Figure P2.19

**SOLUTION:**

$$4I_x + 4mA = I_1$$

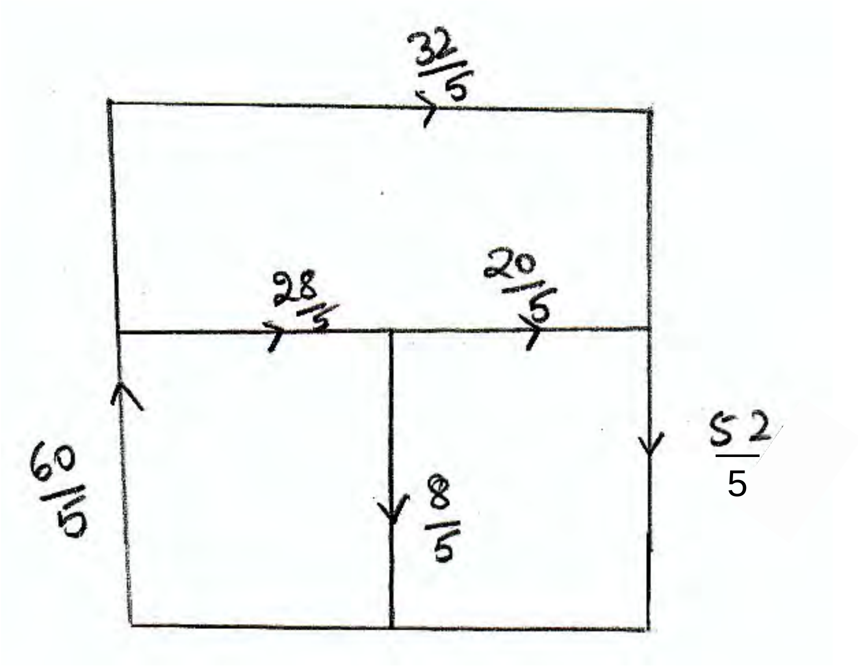
$$I_1 + I_x = 12mA$$

$$4I_x + 4mA + I_x = 12mA$$

$$5I_x = 8mA$$

$$I_x = \frac{8}{5} mA$$

$$I_1 = \frac{32}{5} + \frac{20}{5} = \frac{52}{5} mA$$


32/5
28/5
20/5
60/5
8/5
52/5

**2.20** Find $I_1$ in the network in Fig. P2.20.

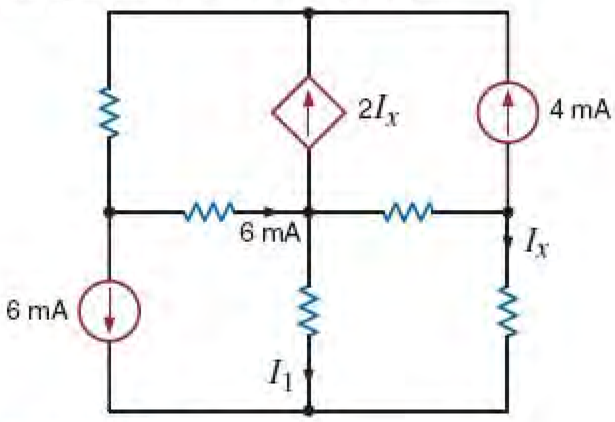



Figure P2.20

## SOLUTION:

$$4mA + 2I_x = 6mA + 6mA$$

$$I_x = 4mA$$

$$6mA + I_1 + I_x = 0$$

$$6mA + I_1 + 4mA = 0$$

$$I_1 = -10mA$$

**2.21** Find $I_1$, $I_2$, and $I_3$ in the network in Fig. P2.21.

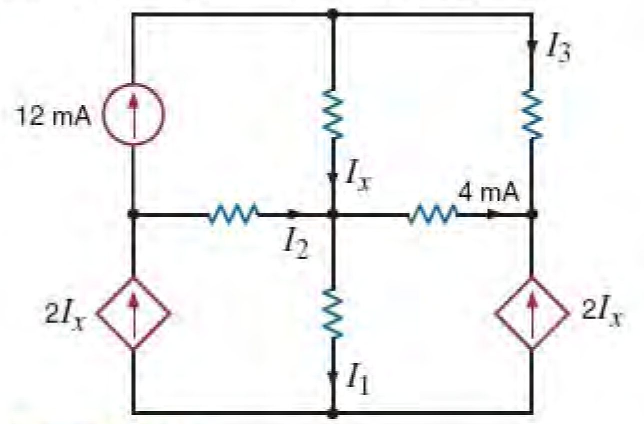



Figure P2.21

**SOLUTION:**

$$12mA + 2I_x + 4mA = I_x$$

$$I_x = -16mA$$

$$I_1 = 2I_x + 2I_x = -64mA$$

$$2I_x = I_2 + 12mA$$

$$-32mA = I_2 + 12mA$$

$$-44mA = I_2$$

$$12mA = I_x + I_3$$

$$12mA = -16mA + I_3$$

$$28mA = I_3$$

**2.22** In the network in Fig. P2.22, Find $I_1$, $I_2$ and $I_3$ and show that KCL is satisfied at the boundary.

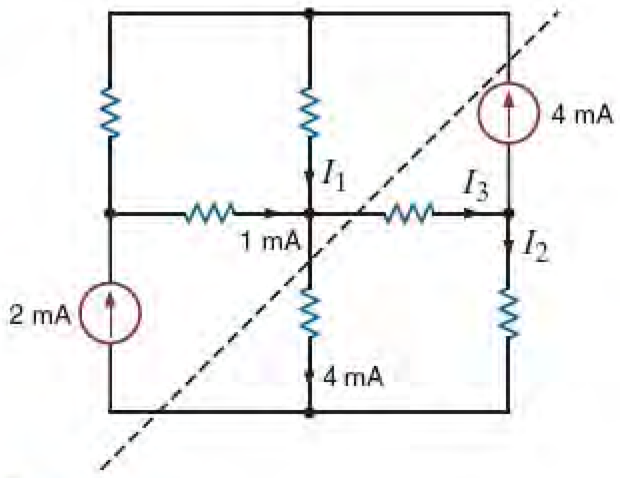



Figure P2.22

**SOLUTION:**

$$2mA - 1mA + 4mA = I_1$$

$$I_1 = 5mA$$

$$I_2 + 4mA = 2mA$$

$$I_2 = -2mA$$

$$I_3 = I_2 + 4mA$$

$$= 2mA$$

Across the Boundary (left -, Right +)

$$-2mA + 4mA + 2mA - 4mA = 0$$

**2.23** Find $V_{bd}$ in the circuit in Fig. P2.23.

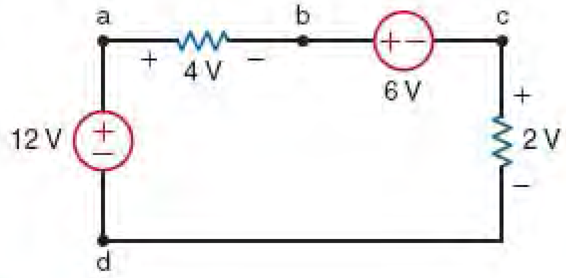



**Figure P2.23**

**SOLUTION:**

$$V_{bd} = V_{bc} + V_{cd}$$

$$V_{bd} = 6+2=8\text{V}$$

**2.24** Find $V_{ad}$ in the network in Fig. P2.24.

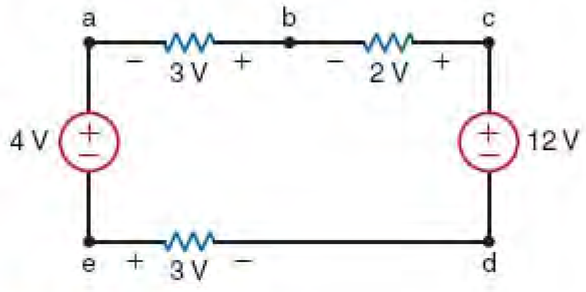



**Figure P2.24**

## SOLUTION:

$$V_{ad} + 3 + 2 = 12$$

$$V_{ad} = 7\text{V}$$

**2.25** Find $V_{fb}$ and $V_{ec}$ in the circuit in Fig. P2.25.

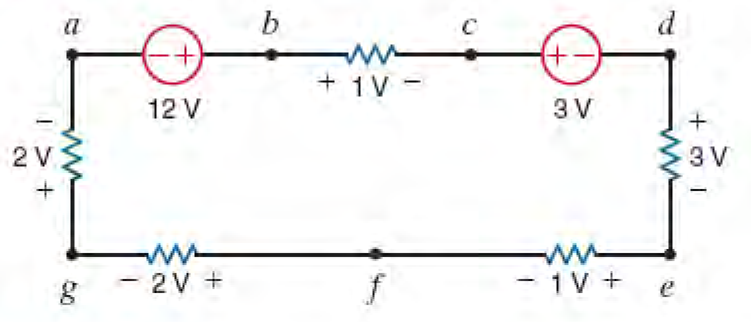



Figure P2.25

**SOLUTION:**

KVL around fbcdef :

$V_{fb} + 1 + 3 + 3 + 1 = 0$

$V_{fb} = -8V$

KVL around ecde :

$V_{ec} + 3 + 3 = 0$

$V_{ec} = -6V$

**2.26** Find $V_{ae}$ and $V_{cf}$ in the circuit in Fig. P2.26.

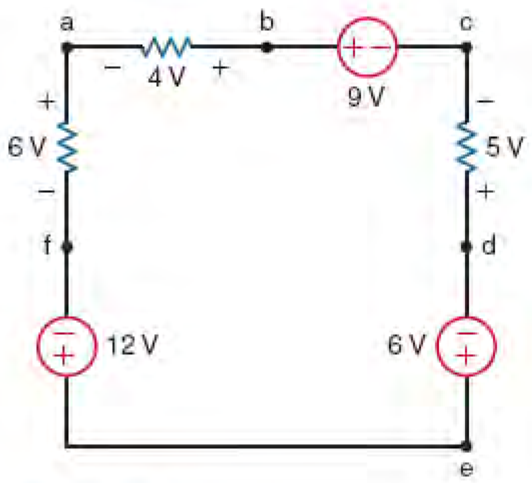



Figure P2.26

**SOLUTION:**

KVL around aefa :

$V_{ae} + 12 = 6$

$V_{ae} = -6\,V$

KVL around cfedc :

$V_{cf} + 5 + 6 = 12$

$V_{cf} = 1\,V$

**2.27** Given the circuit diagram in Fig. P2.27, find the following voltages: $V_{da}$, $V_{bh}$, $V_{gc}$, $V_{di}$, $V_{fa}$, $V_{ac}$, $V_{ai}$, $V_{hf}$, $V_{fb}$, and $V_{dc}$.

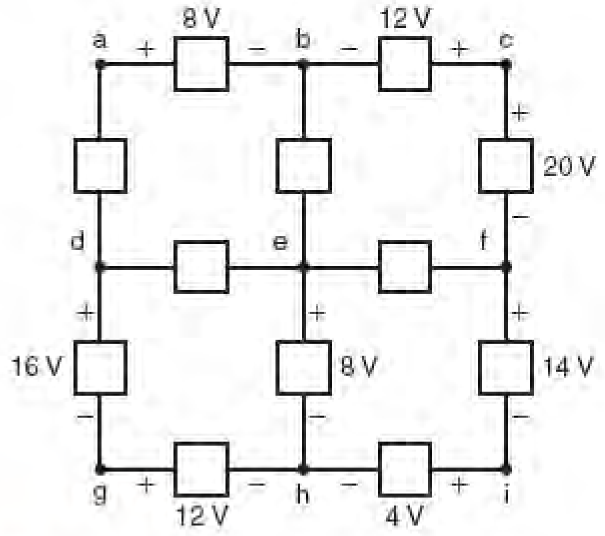



Figure P2.27

## SOLUTION:

KVL : $V_{eh} = V_{ef} + V_{fi} + V_{ih}$

$V_{ef} = 8 - 14 - 4$

$V_{ef} = -10V$

KVL : $V_{de} + V_{ef} + V_{fi} + V_{ih} = V_{dg} + V_{gh}$

$V_{de} = 16 + 12 - (-10) - 14 - 4$

$V_{de} = 20V$

KVL : $V_{ef} + V_{be} + V_{cb} = V_{cf}$

$V_{be} = 20 - (-10) - 12$

$V_{be} = 18V$

KVL : $V_{de} = V_{da} + V_{ab} + V_{be}$

$V_{da} = 20 - 8 - 18$

$\boxed{V_{da} = -6V}$

$V_{bh} = V_{be} + V_{eh} = 18 + 8$

$\boxed{V_{bh} = 26V}$

KVL : $V_{gh} = V_{gc} + V_{ih} + V_{fi} + V_{cf}$

$V_{gc} = 12 - 4 - 14 - 20$

$\boxed{V_{gc} = -26V}$

KVL : $V_{di} + V_{ih} = V_{dg} + V_{gh}$

$V_{di} = -4 + 16 + 12$

$\boxed{V_{di} = 24V}$

KVL : $V_{fa} + V_{ab} + V_{cf} = V_{cb}$

$V_{fa} = 12 - 8 - 20$

$\boxed{V_{fa} = -16V}$

KVL : $V_{ac} + V_{cb} = V_{ab}$

$V_{ac} = 8 - 12$

$V_{ac} = -4V$

KVL : $V_{cf} + V_{fi} + V_{ia} + V_{ab} = V_{cb}$

$V_{ia} = 12 - 14 - 8 - 20$

$V_{ia} = -30V$

KVL : $V_{hf} + V_{fi} + V_{in} = 0$

$V_{hf} = -14 - 4$

$\boxed{V_{hf} = -18V}$

KVL : $V_{fb} + V_{cf} = V_{cb}$

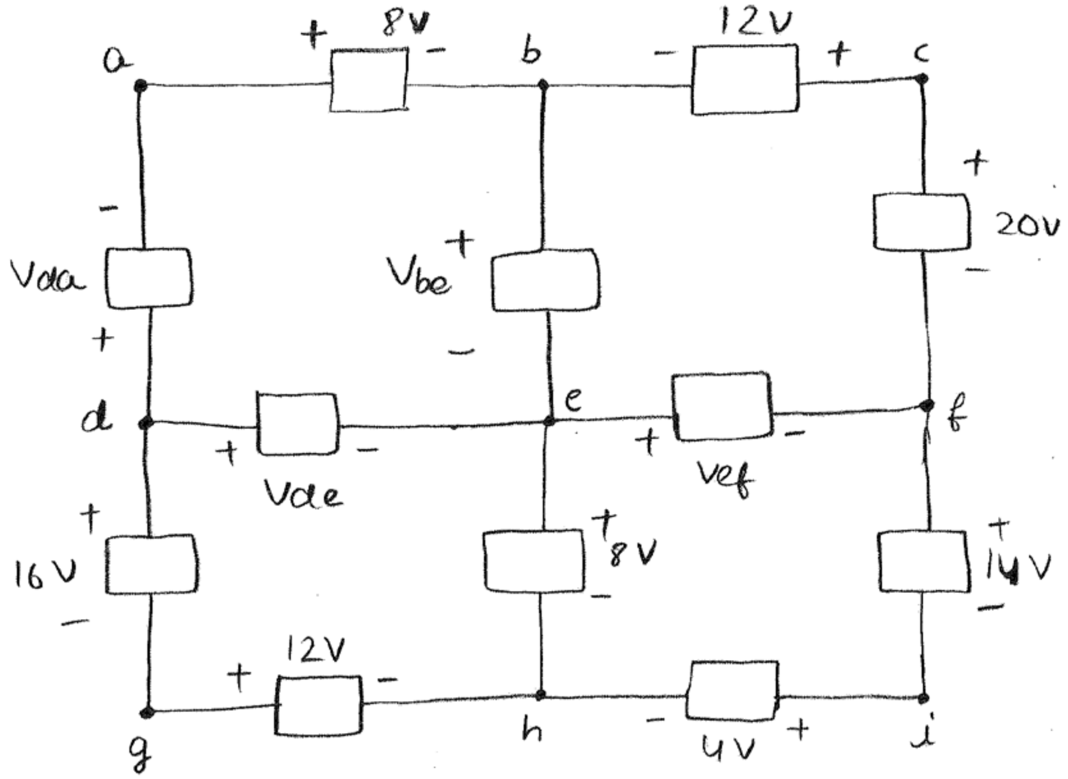
$V_{fb} = 12 - 20$

$V_{fb} = -8V$

KVL : $V_{dc} + V_{cf} = V_{ef} + V_{de}$

$V_{dc} = -10 + 20 - 20$

$\boxed{V_{dc} = -10V}$


a
+ 8V −
b
− 12V +
c
−
Vda
+
Vbe
+
−
+
20V
−
d
+ Vde −
e
+ Vef −
f
+
16V
−
+
8V
−
+
14V
−
+ 12V −
g
h
− 4V +
i

**2.28** Find $V_x$ and $V_y$ in the circuit in Fig. P2.28.

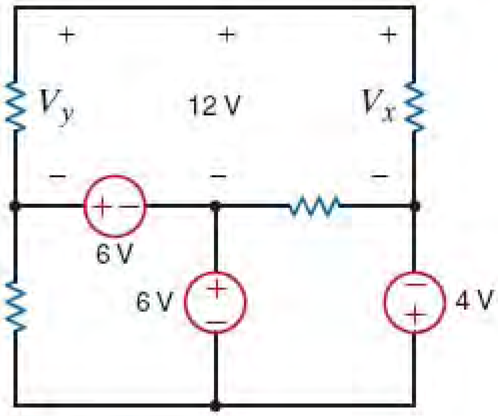



Figure P2.28

## SOLUTION:

$$-6 - 12 + V_x - 4 = 0$$

$$V_x = 22V$$

$$-6 - V_y + 12 = 0$$

$$V_y = 6V$$

**2.29** Find $V_x$ and $V_y$ in the circuit in Fig. P2.29.

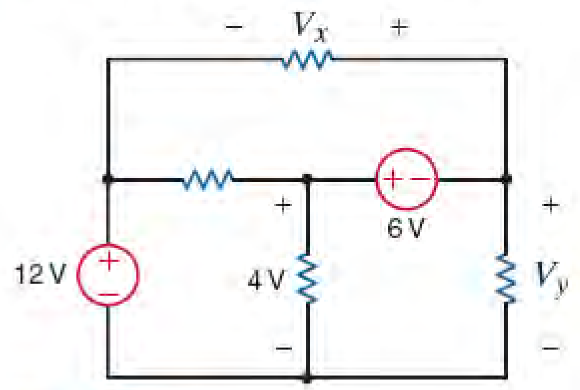



Figure P2.29

## SOLUTION:

$$-12 - V_x - 6 + 4 = 0$$

$$V_x = -14V$$

$$-4 + 6 + V_y = 0$$

$$V_y = -2V$$

**2.30** Find $V_1$, $V_2$ and $V_3$ in the network in Fig. P2.30.

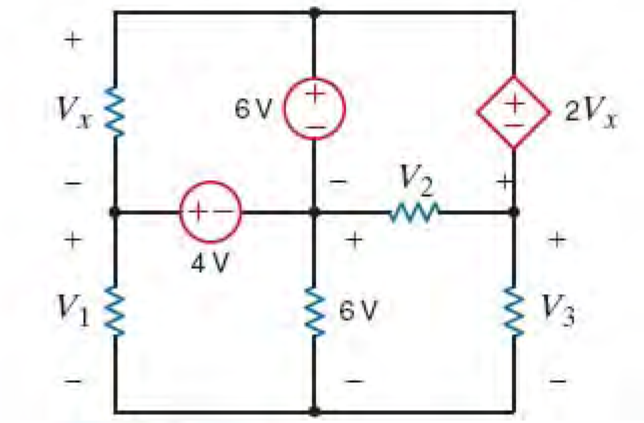



Figure P2.30

## SOLUTION:

$$-V_1 + 4 + 6 = 0$$
$$V_1 = 10V$$

$$-V_x + 6 - 4 = 0$$
$$V_x = 2V$$

$$-6 + 2V_x + V_2 = 0$$
$$-6 + 4 + V_2 = 0$$
$$V_2 = 2V$$

$$-6 - V_2 + V_3 = 0$$
$$-6 - 2 + V_3 = 0$$
$$V_3 = 8V$$

**2.31** Find $V_o$ in the network in Fig. P2.31.

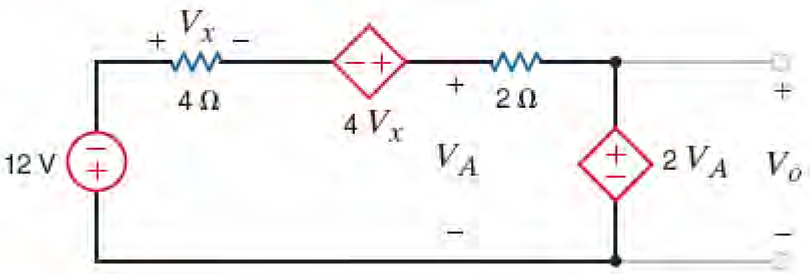



Figure P2.31

**SOLUTION:**

KVL : $4V_x = 12 + 4I + 2I + 2V_A$

$V_x = 4I$

$4(4I) = 12 + 6I + 2V_A$

$2V_A = 10I - 12$

$V_A = 5I - 6$

KVL : $4V_x = 12 + V_x + V_A$

$4(4I) = 12 + 4I + V_A$

$V_A = 12I - 12$

$I = \frac{V_A + 12}{12}$

$V_A = 5\left(\frac{V_A + 12}{12}\right) - 6$

$12V_A = 5V_A + 60 - 72$

$7V_A = -12$

$V_A = -\frac{12}{7}$ V

$V_o = 2V_A = 2\left(\frac{-12}{7}\right) = \frac{-24}{7}$ V

**2.32** Find $V_o$ in the circuit in Fig. P2.32.

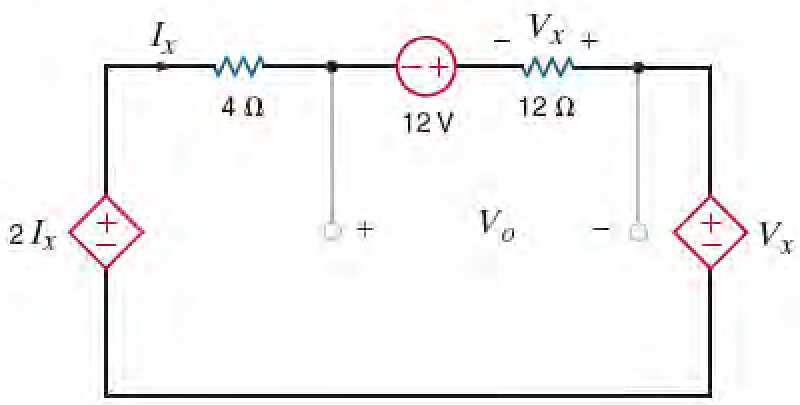



Figure P2.32

## SOLUTION:

KVL:

$$V_o + 12 + V_x = 0$$
$$V_o = -V_x - 12$$
$$V_x = -12 I_x$$

KVL around outer loop:

$$2I_x + 12 + V_x = 4I_x + V_x$$
$$2I_x + 12 + 12I_x = 4I_x + 12I_x$$
$$2I_x = 12$$
$$I_x = 6A$$

$$V_x = -12(6) = -72\text{ V}$$
$$V_o = -(-72) - 12$$
$$V_o = 60\text{ V}$$

**2.33** The 10-V source absorbs 2.5 mW of power. Calculate $V_{ba}$ and the power absorbed by the dependent voltage source in Fig. P2.33.

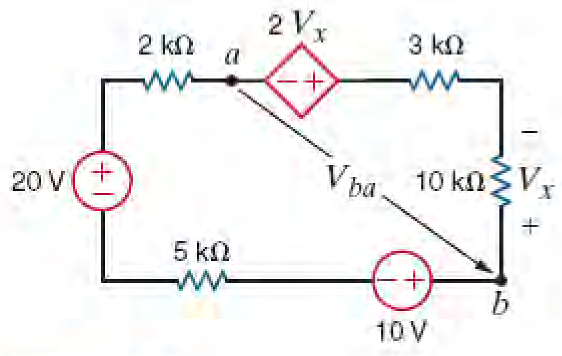



Figure P2.33

**SOLUTION:**

$$P_{10V} = 2.5\,mW$$

$$P_{10V} = 2.5m = 10I$$

$$I = 250\mu A$$

$$KVL: \; V_{ba} + 20 = 10 + 5KI + 2KI$$

$$V_{ba} = -10 + 5K(250\mu) + 2K(250\mu)$$

$$V_{ba} = -8.25\,V$$

$$P_{2V_x} = -2V_x(I)$$

$$V_x = -I(10k) = -(250\mu)(10k)$$

$$V_x = -2.5V$$

$$P_{2V_x} = -2(-2.5)(250\mu)$$

$$P_{2V_x} = 1.25\,mW$$

**2.34** Find $V_1$, $V_2$, and $V_3$ in the network in Fig. P2.34.

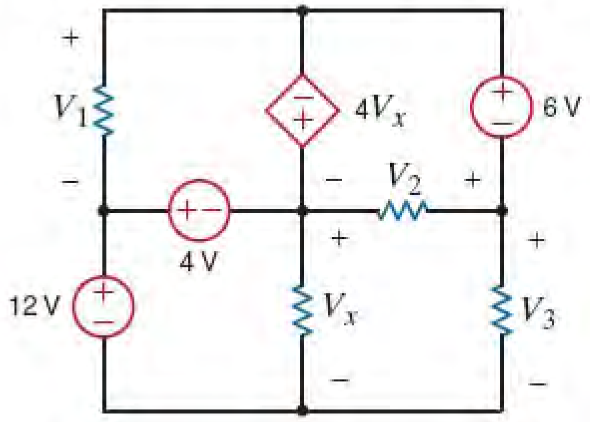



Figure P2.34

## SOLUTION:

$$-12+4+V_x=0$$
$$V_x=8V$$

$$-V_1-4V_x-4=0$$
$$-V_1-32-4=0$$
$$V_1=-36V$$

$$4V_x+6+V_2=0$$
$$32+6+V_2=0$$
$$V_2=-38V$$

$$-V_x-V_2+V_3=0$$
$$V_3=V_x+V_2$$
$$=8-38$$
$$=-30V$$

**2.35** The 10-V source in Fig. P.2.35 is supplying 50 W. Determine $R_1$.

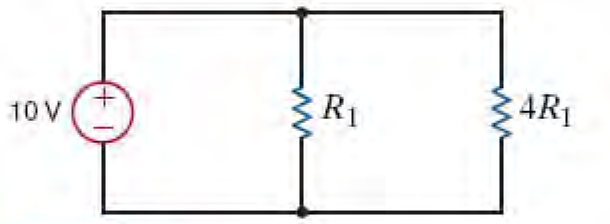
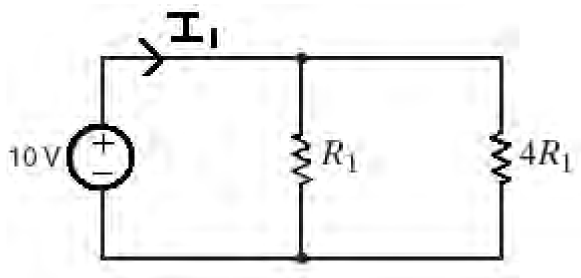


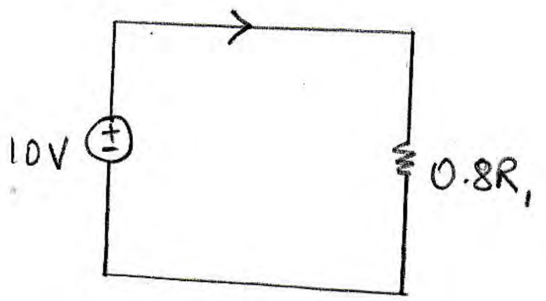

Figure P2.35

**SOLUTION:**




$50 = 10I_1$ $\qquad I_1 = \frac{50}{10} = 5A$

$I_1 = 5A$




$$\frac{(R_1)(4R_1)}{R_1 + 4R_1}$$

$$0.8R_1 = \frac{10}{5} = 2\,\Omega$$

$$R_1 = \frac{2}{0.8} = \underline{2.5\,\Omega}$$

**2.36** Find $V_1$ and $V_2$ in Fig. P2.36.

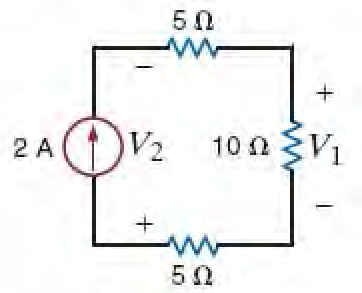
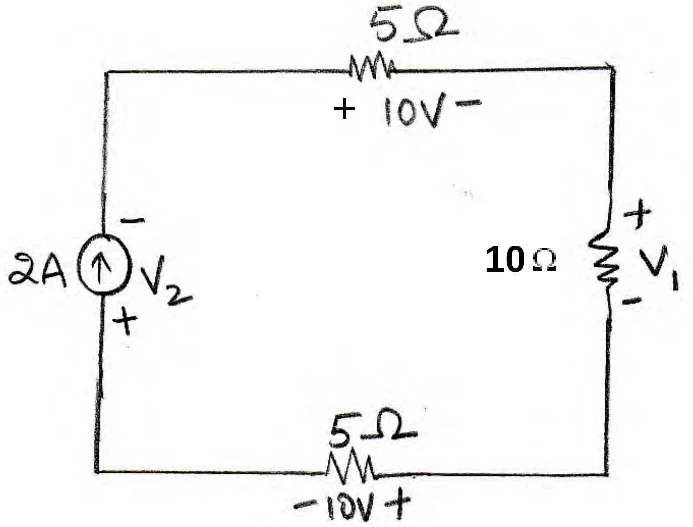



Figure P2.36

**SOLUTION:**




$$V_1 = (2)(10) = 20V$$

$$V_2 = -10 - 20 - 10 = \underline{-40V}$$

**2.37** Find $V_{bd}$ in the network in Fig. P2.37.

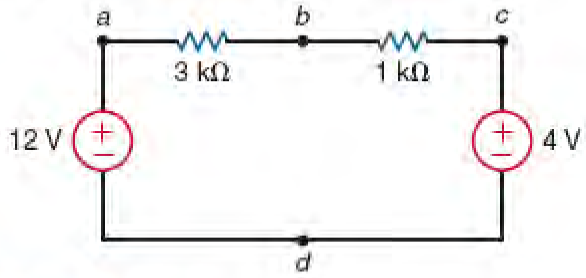



Figure P2.37

**SOLUTION:**

KVL: $12 = 3KI + 1KI + 4$

$4KI = 8$

$I = 2mA$

KVL left loop: $12 = 3KI + V_{bd}$

$V_{bd} = 12 - 3K(2m)$

$V_{bd} = 6V$

**2.38** Find $V_x$ in the circuit in Fig. P2.38.

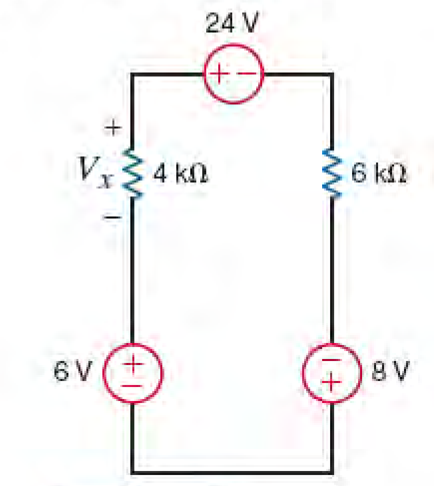



**Figure P2.38**

**SOLUTION:**

KVL:

$24 = 4kI + 6 + 8 + 6kI$

$10kI = 10$

$I = 1mA$

$V_x = I(4k) = (1m)(4k)$

$V_x = 4V$

**2.39** Find $V_{ab}$ in the network in Fig. P2.39.

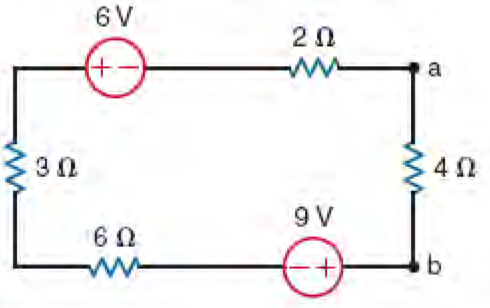



Figure P2.39

**SOLUTION:**

$V_{ab} = -4I$

KVL: $6 + 9 = 4I + 2I + 3I + 6I$

$15I = 15$

$I = 1A$

$V_{ab} = -4(1)$

$V_{ab} = -4V$

**2.40** Find $V_x$ and the power supplied by the 15-V source in the circuit in Fig. P2.40.

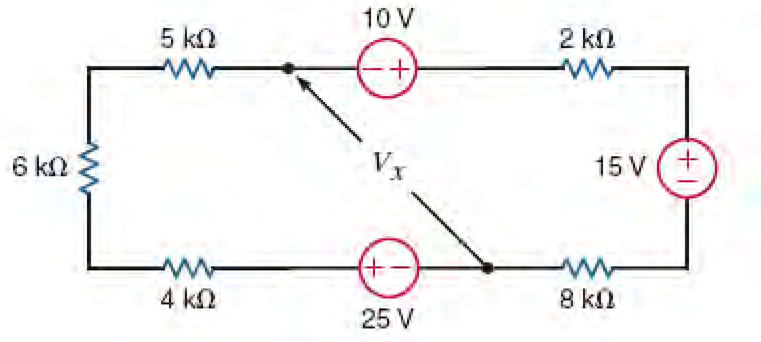



**Figure P2.40**

**SOLUTION:**

KVL : $25 + 10 = 4KI + 6KI + 5KI + 2KI + 15 + 8KI$

$25KI = 20$

$I = 0.8mA$

KVL : $V_x + 10 = 2KI + 15 + 8KI$

$V_x = 5 + 10K(0.8m)$

$V_x = 13V$

$P_{15V} = VI = 15(0.8m)$

$P_{15V} = 12\ mW$ (absorbed)

**2.41** Find $V_1$ in the network in Fig. P2.41.

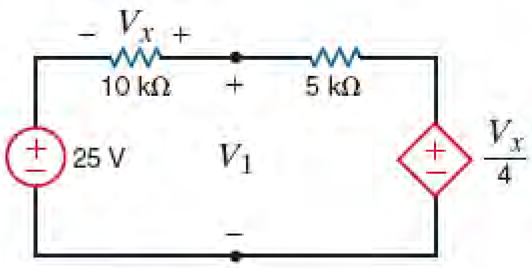



Figure P2.41

## SOLUTION:

KVL : $25 = 10KI + 5KI + \frac{V_x}{4}$

$V_x = -10KI$

$25 = 15KI - \frac{10KI}{4}$

$100 = 60KI - 10KI$

$50KI = 100$

$I = 2mA$

$V_x = -10K(2m)$

$V_x = -20V$

KVL : $V_1 = 5KI + \frac{V_x}{4}$

$V_1 = 5K(2m) + \frac{-20}{4}$

$V_1 = 5V$

**2.42** Find the power supplied by each source, including the dependent source, in Fig. P2.42.

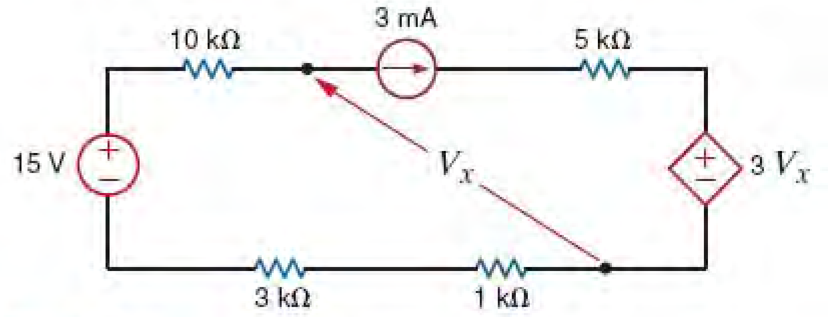
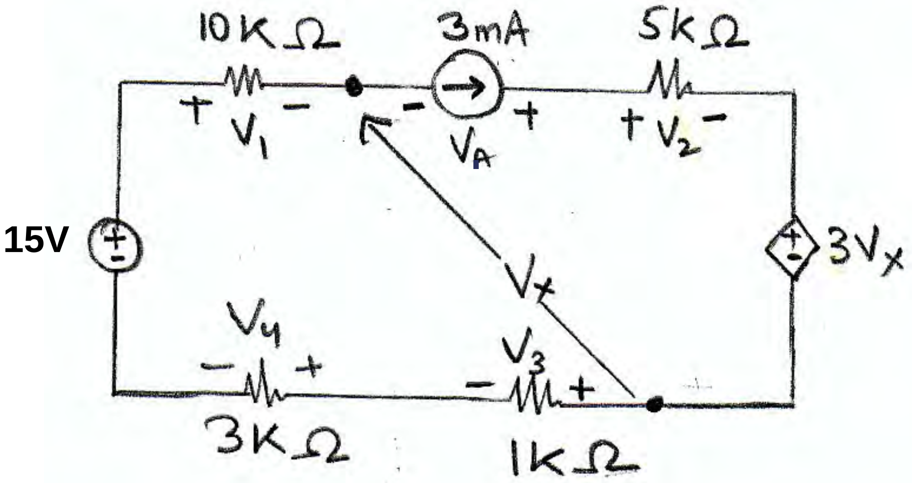



**Figure P2.42**

**SOLUTION:**




$$V_1 = (10k)(3m) = 30V$$

$$V_2 = (5K)(3m) = 15V$$

$$V_3 = (1K)(3m) = 3V$$

$$V_4 = (3k)(3m) = 9V$$

$$V_x = -V_1 + 15 - V_4 - V_3$$

$$V_x = -30 + 15 - 9 - 3 = -27V$$

$$15V: \; P = (15)(3m) = \underline{45\,mW}$$

$$V_A = V_2 + 3V_x - V_x = V_2 + 2V_x$$

$$V_A = 15 + 2(-27) = -39\,V$$

$$3mA: \; P = (-39)(3m) = \underline{-117\,mW}$$

$$3V_x: \; P = -(3V_x)(3m) = -(3)(-27)(3m)$$

$$= \underline{243\,mW}$$

**2.43** Find the power absorbed by the dependent voltage source in the circuit in Fig. P2.43.

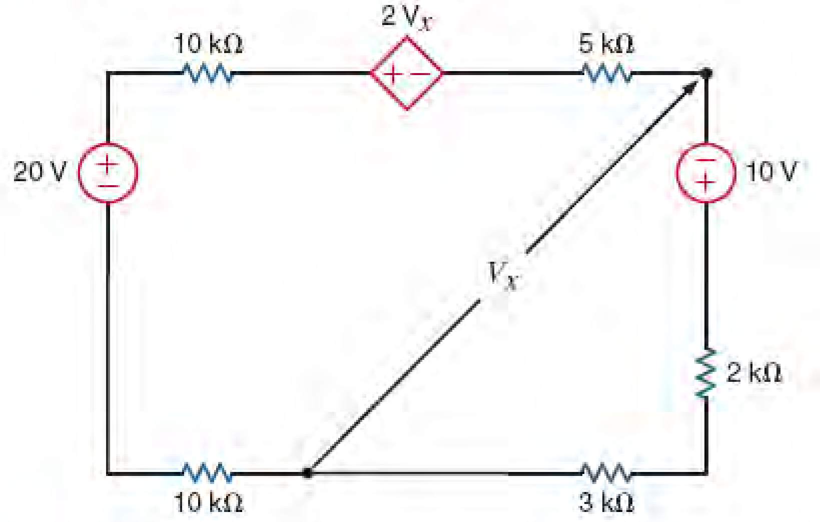



**Figure P2.43**

**SOLUTION:**

$$\text{KVL: } 20+10 = 10kI + 2V_x + 5kI + 2kI + 3kI + 10kI$$

$$30 = 30kI + 2V_x$$

$$I = 1m - \frac{1}{15}m\,V_x$$

$$\text{KVL: } V_x + 10 = 2kI + 3kI$$

$$V_x = 5k\left(1m - 1/15m\,V_x\right) - 10$$

$$V_x = 5 - \frac{1}{3}V_x - 10$$

$$3V_x = 15 - V_x - 30$$

$$4V_x = -15$$

$$V_x = -3.75\text{ V}$$

$$I = 1m - \frac{1}{15}m\,(-3.75)$$

$I = 1.25\,mA$

$P = 2V_x(I)$

$P = 2(-3.75)(1.25m)$

$P = -9.375\,mW$

**2.44** Find the power absorbed by the dependent source in the circuit in Fig. P2.44.

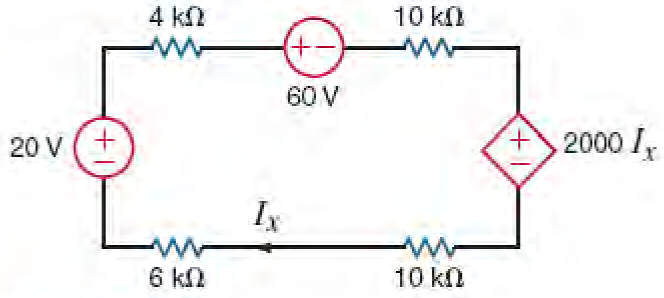



**Figure P2.44**

## SOLUTION:

KVL:

$$20 = 6KI_x + 4KI_x + 60 + 10KI_x + 2KI_x + 10KI_x$$

$$32KI_x = -40$$

$$I_x = 1.25mA$$

$$P = (2000I_x)(I_x)$$

$$P = \{200(-1.25m)\}(-1.25m)$$

$$P = 3.125\,mW$$

**2.45** The 100-V source in the circuit in Fig. P2.45 is supplying 200 W. Solve for $V_2$.

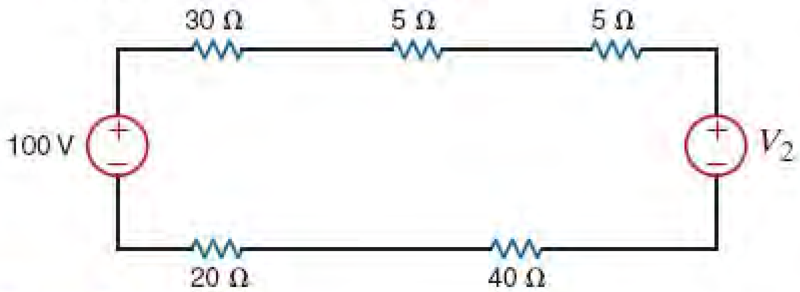
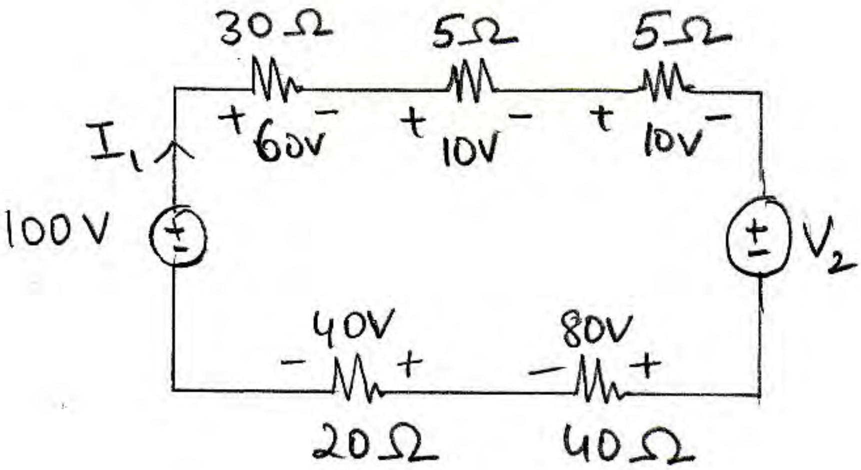



Figure P2.45

**SOLUTION:**




$$200 = 100 I_1 \qquad I_1 = 2A$$

$$60 + 10 + 10 + V_2 + 80 + 40 - 100 = 0$$

$$V_2 = -100V$$

**2.46** Find the value of $V_2$ in Fig. P2.46 such that $V_1 = 0$.

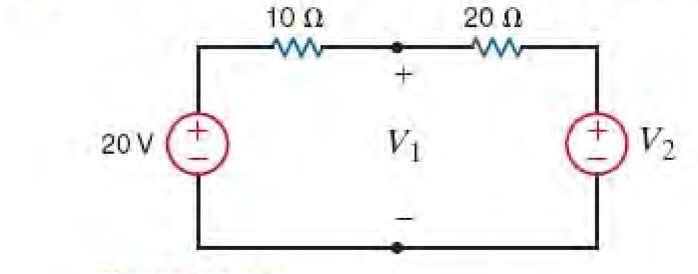
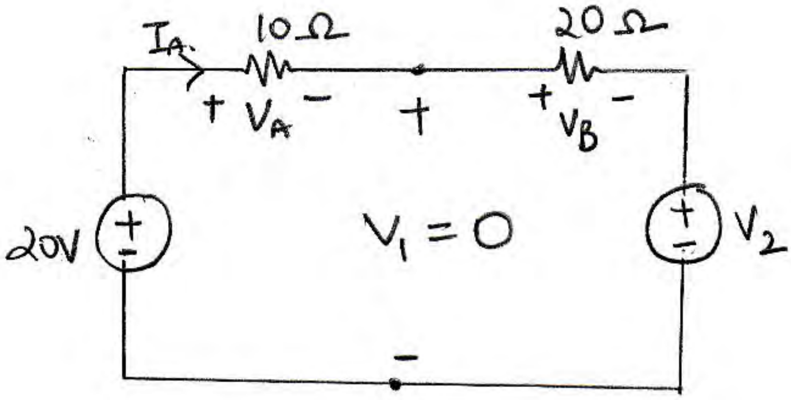



Figure P2.46

**SOLUTION:**




$$V_A = 20V$$

$$I_A = \frac{20}{10} = 2A$$

$$V_B = (20)(2) = 40V$$

$$V_B + V_2 = V_1 = 0$$

$$V_2 = -V_B$$

$$V_2 = -40V$$

**2.47** Find $I_o$ in the network in Fig. P2.47.

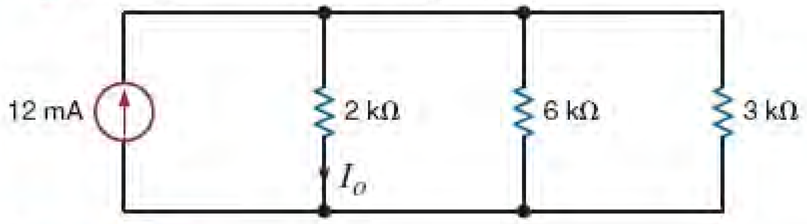
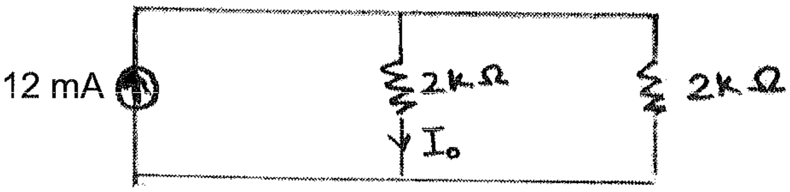



Figure P2.47

**SOLUTION:**

$$6K \| 3K = 2K\,\Omega$$




$$I_o = \left(\frac{2k}{2k+2k}\right)(12m)$$

$$I_o = 6mA$$

**2.48** Find $I_o$ in the network in Fig. P2.48.

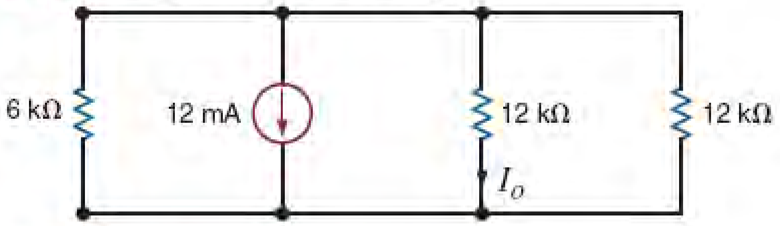
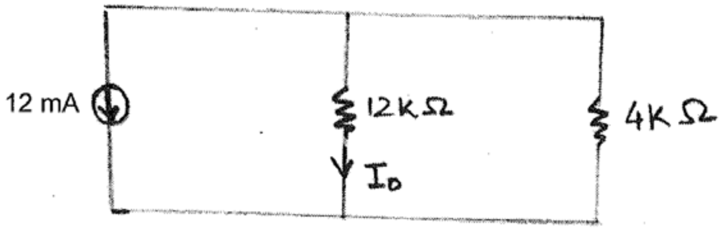



**Figure P2.48**

**SOLUTION:**

$$6K \| 12K = 4K\Omega$$




$$I_o = \left(\frac{4k}{4K+12K}\right)(-12m)$$

$$I_o = -3mA$$

**2.49** Find the power supplied by each source in the circuit in Fig. P2.49.

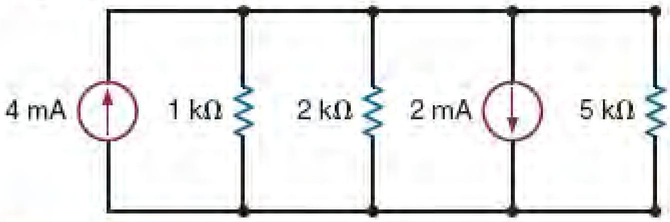
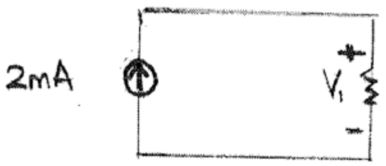



Figure P2.49

**SOLUTION:**

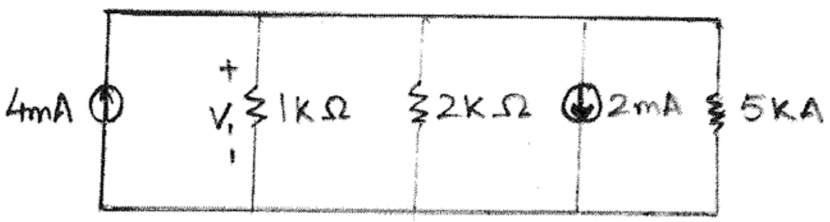



$R_{eq} = (1k \| 2k) \| 5k$

$R_{eq} = 588.24\,\Omega$

$V_1 = 2m(588.24)$

$V_1 = 1.18\,V$




$P_{4mA} = 4m\,(1.18)$

$P_{4mA} = 4.72\ mW$

$P_{2mA} = (-2m)(1.18)$

$P_{2mA} = -2.36\ mW$

**2.50** Find the current $I_A$ in the circuit in Fig. P2.50.

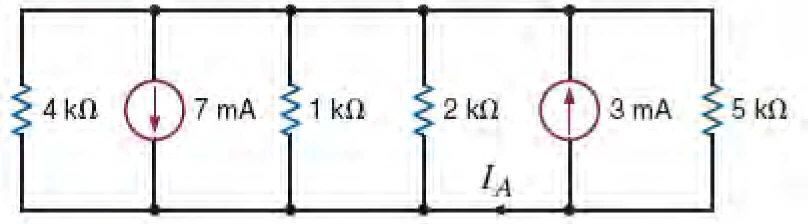
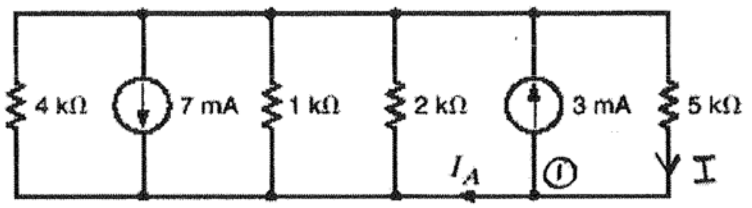
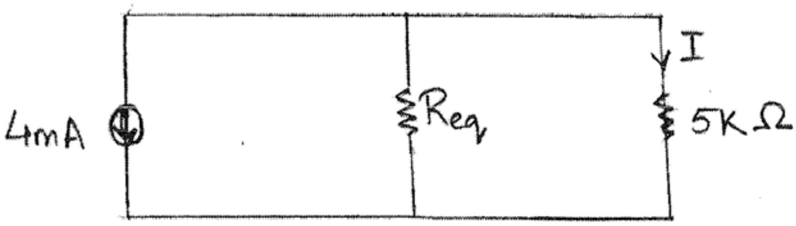



Figure P2.50

## SOLUTION:




$$I = \left(\frac{R_{eq}}{R_{eq} + 5K}\right)(-4m)$$

$$I = -0.41mA$$

KCL at 1 :

$$I = 3m + I_A$$

$$I_A = -0.41m - 3m$$

$$\boxed{I_A = -3.41mA}$$

**2.51** Find $I_o$ in the network in Fig. P2.51.

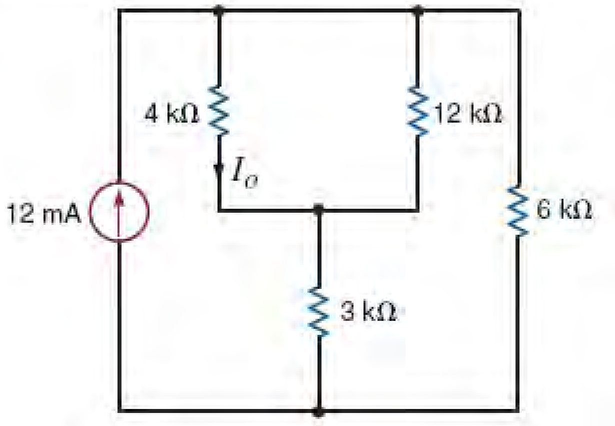
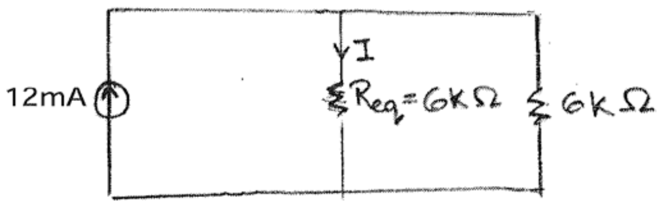



Figure P2.51

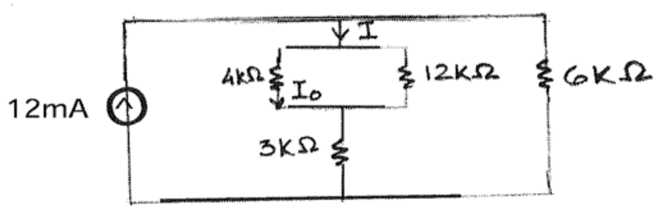
## SOLUTION:

$$R_{eq} = (4K \| 12K) + 3K$$

$$R_{eq} = 6K\Omega$$




$$I = \left(\frac{6K}{6K+6K}\right)(12m) = 6mA$$




$$I_o = \left(\frac{12K}{12K+4K}\right)(6m)$$

$$I_o = 4.5mA$$

**2.52** Find $I_o$ in the network in Fig. P2.52.

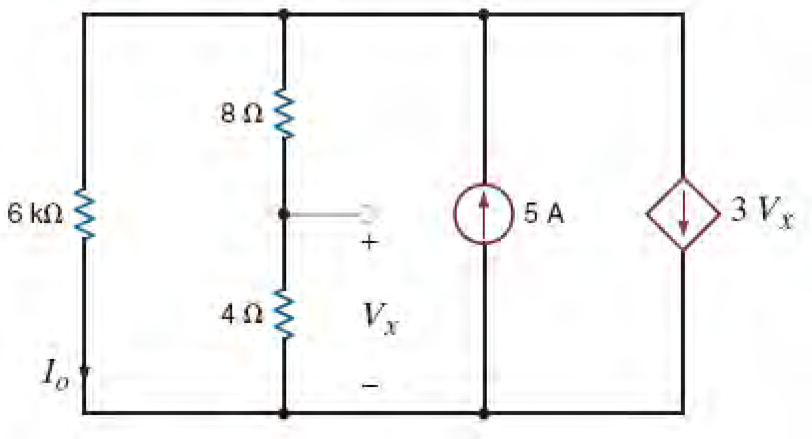



Figure P2.52

**SOLUTION:**

$$KCL: \quad 5 = \frac{V_1}{6} + \frac{V_1}{8+4} + 3V_x$$

$$V_x = \left(\frac{4}{4+8}\right)(V_1)$$

$$V_x = \frac{V_1}{3}$$

$$5 = \frac{V_1}{6} + \frac{V_1}{12} + 3\left(\frac{V_1}{3}\right)$$

$$60 = 2V_1 + V_1 + 12V_1$$

$$15V_1 = 60$$

$$V_1 = 4V$$

$$V_1 = 6I_o$$

$$I_o = \frac{V_1}{6}$$

$$I_o = \frac{4}{6}$$

$$I_o = \frac{2}{3}\,A$$

**2.53** Determine $I_L$ in the circuit in Fig. P2.53.

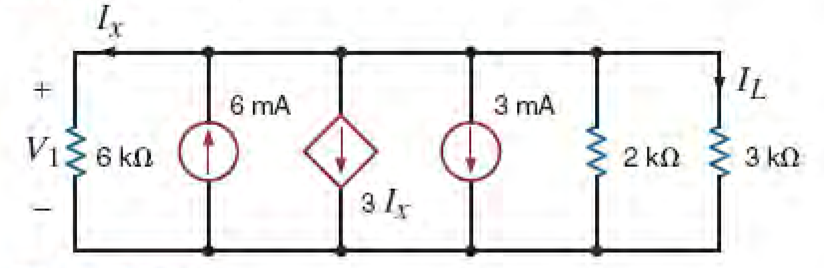
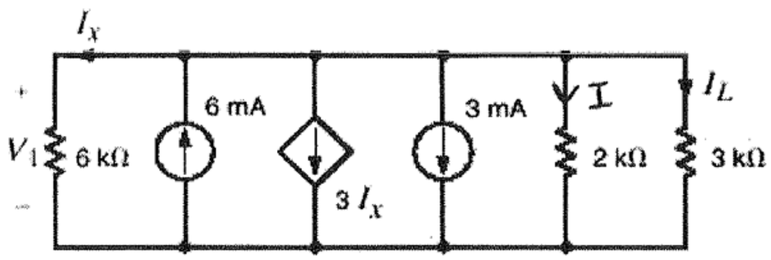



Figure P2.53

**SOLUTION:**




KCL :

$$6m = \frac{V_1}{6K} + 3I_x + 3m + \frac{V_1}{2K} + \frac{V_1}{3K}$$

$$I_x = \frac{V_1}{6K}$$

$$6m = \frac{V_1}{6K} + 3\left(\frac{V_1}{6K}\right) + 3m + \frac{V_1}{2K} + \frac{V_1}{3K}$$

$$36 = V_1 + 3V_1 + 18 + 3V_1 + 2V_1$$

$$9V_1 = 18$$

$$V_1 = 2V$$

$$I_x = \frac{2}{6K} = \frac{1}{3}mA$$

KCL :

$$6m = I_x + 3I_x + 3m + \frac{V_1}{2k} + I_L$$

$$6m = \frac{1}{3}m + 3\left(\frac{1}{3}m\right) + 3m + \frac{2}{2k} + I_L$$

$$I_L = 3m - \frac{1}{3}m - 1m - 1m$$

$$I_L = \frac{2}{3}mA$$

**2.54** Find the power absorbed by the dependent source in the network in Fig. P2.54.

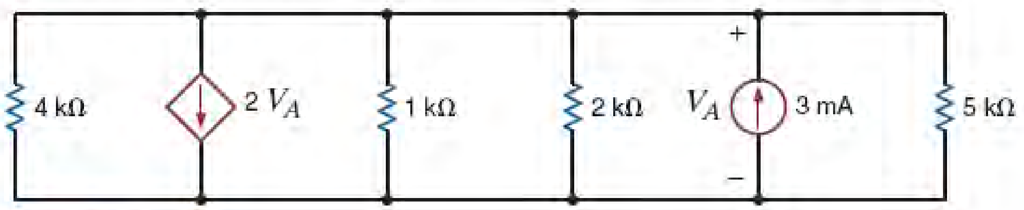
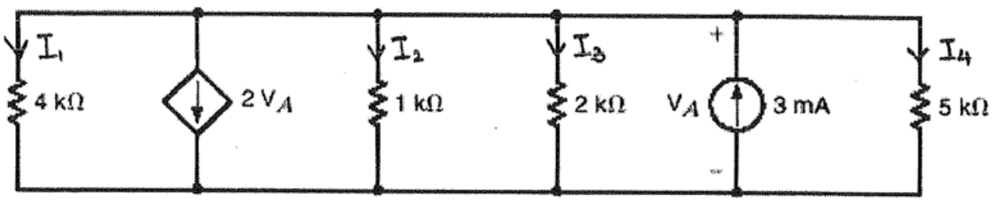



Figure P2.54

## SOLUTION:




KCL: $3m = I_1 + 2V_A + I_2 + I_3 + I_4$

$$I_1 = \frac{V_A}{4K}, \quad I_2 = \frac{V_A}{1K}, \quad I_3 = \frac{V_A}{2K}, \text{ and } I_4 = \frac{V_A}{5K}$$

$$3m = \frac{V_A}{4K} + 2V_A + \frac{V_A}{1K} + \frac{V_A}{2K} + \frac{V_A}{5K}$$

$$60 = 5V_A + 40KV_A + 20V_A + 10V_A + 4V_A$$

$$V_A = 1.5mV$$

$$P_{2VA} = V_A I = V_A(2V_A)$$

$$P_{2VA} = 1.5m(2)(1.5m)$$

$$P_{2VA} = 4.5\mu W$$

**2.55** Find $R_{AB}$ in the circuit in Fig. P2.55.

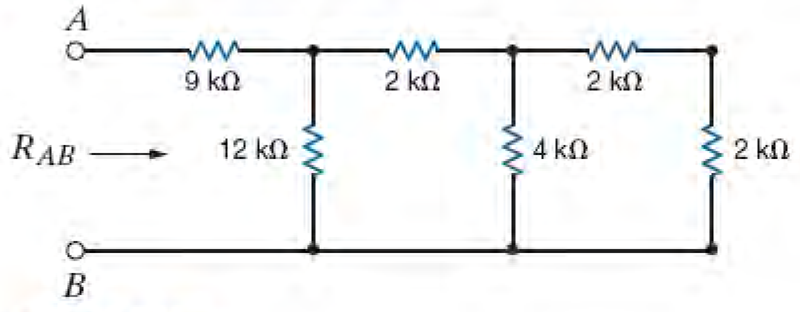
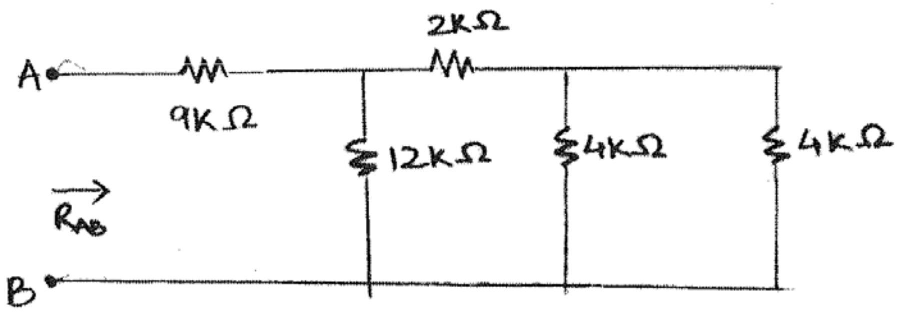



**Figure P2.55**

**SOLUTION:**




$$R_{AB} = \{[(4K \| 4K) + 2K] \| 12K\} + 9K$$

$$R_{AB} = (4K \| 12K) + 9K$$

$$R_{AB} = \frac{4K(12K)}{4K + 12K} + 9K$$

$$R_{AB} = 12K\,\Omega$$

**2.56** Find $R_{AB}$ in the network in Fig. P2.56.

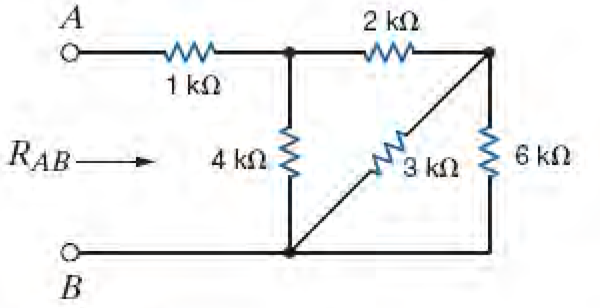
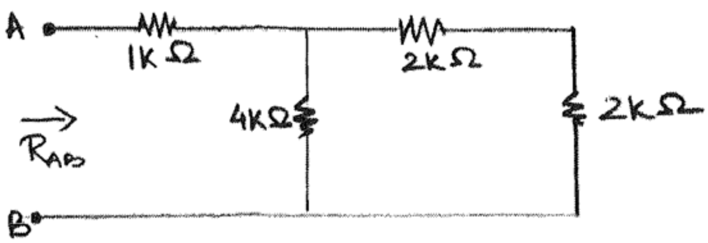



Figure P2.56

**SOLUTION:**

$3K \| 6K = 2K\Omega$




$R_{AB} = (4K \| 4K) + 1K$

$R_{AB} = 3K\Omega$

**2.57** Find $R_{AB}$ in the circuit in Fig. P2.57.

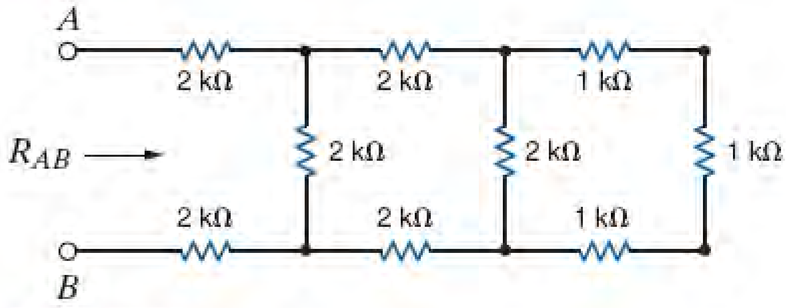
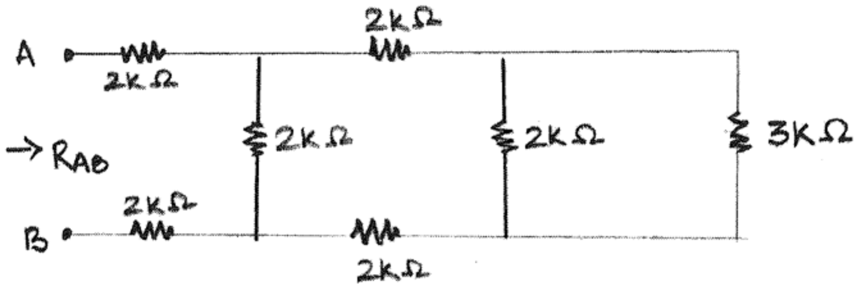
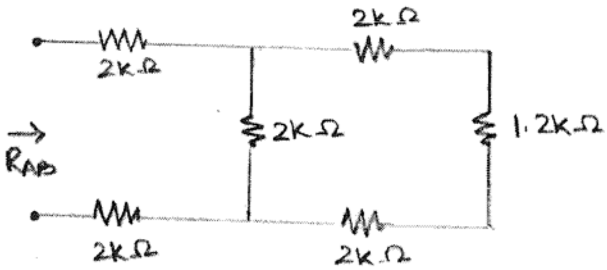


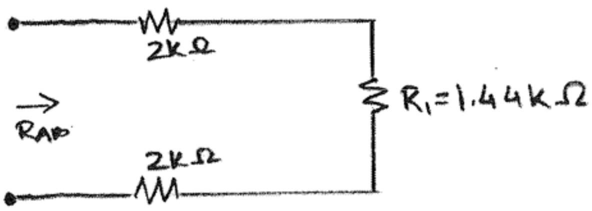

**Figure P2.57**

**SOLUTION:**




$$2K\,\Omega \,||\, 3K\,\Omega = 1.2K\,\Omega$$




$$R_1 = (2k + 1.2k + 2k) \,||\, 2k$$

$$R_1 = 1.44K\,\Omega$$

$$R_{AB} = 2K + 1.44k + 2K$$

$$R_{AB} = 5.44K\,\Omega$$

**2.58** Find $R_{AB}$ in the network in Fig. P2.58.

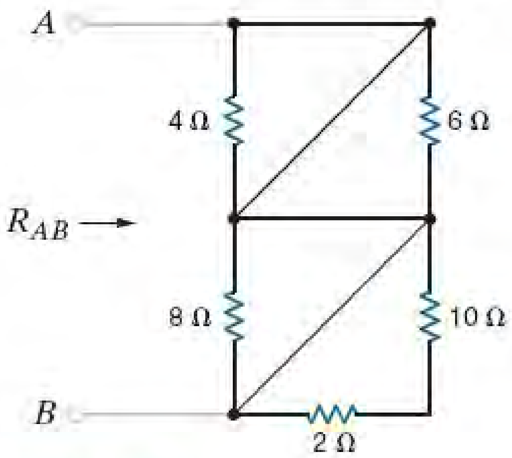



Figure P2.58

## SOLUTION:

$$R_{AB} = 0$$

**2.59** Find $R_{AB}$ in the circuit in Fig. P2.59.

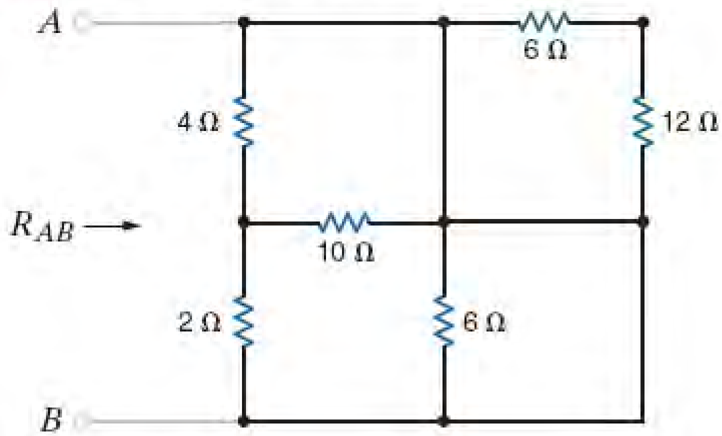



**Figure P2.59**

**SOLUTION:**

$$R_{AB} = 0$$

**2.60** Find $R_{AB}$ in the network in Fig. P2.60.

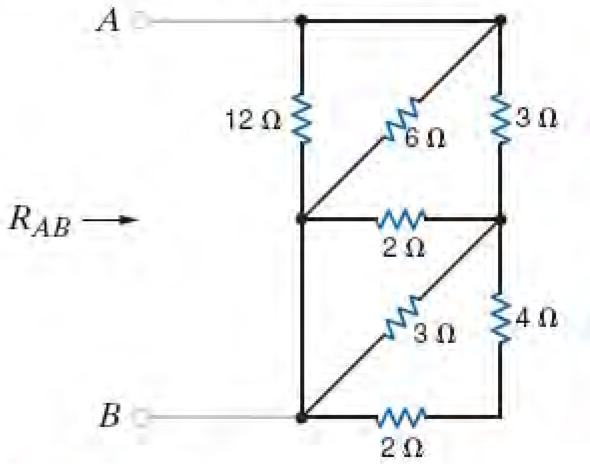
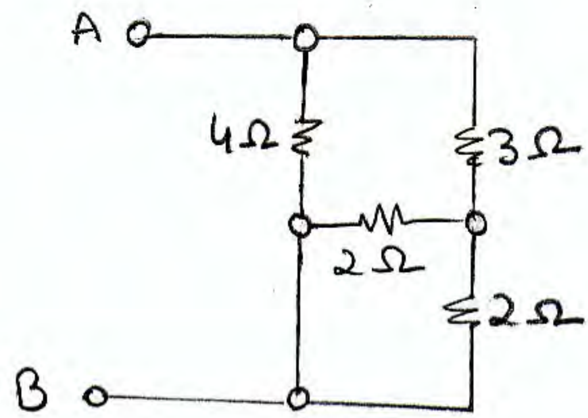
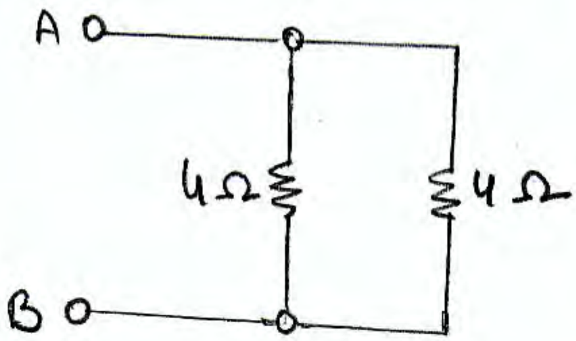



**Figure P2.60**

## SOLUTION:




$R_{AB} = 2\,\Omega$

**2.61** Find $R_{AB}$ in the circuit in Fig. P2.61.

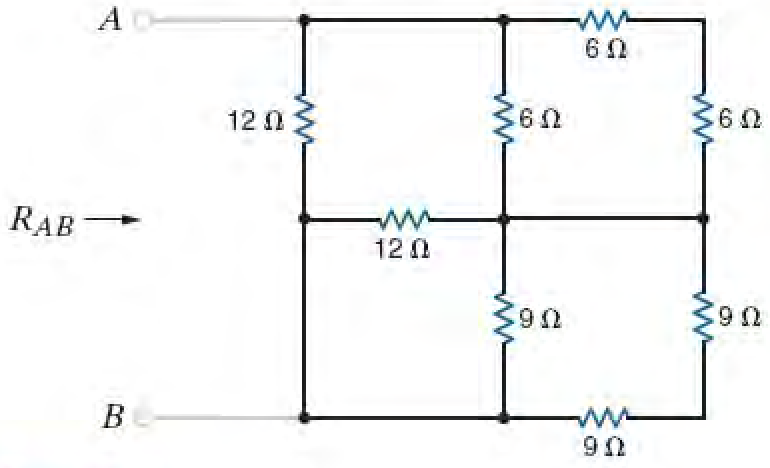
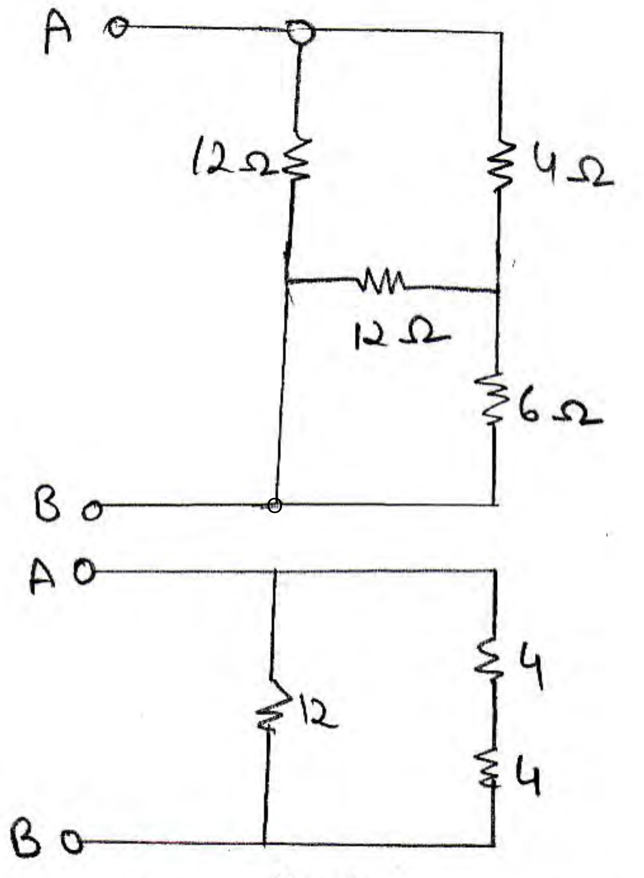



Figure P2.61

## SOLUTION:




$$R_{AB} = \frac{12 \times 8}{20} = 4.8\,\Omega$$

**2.62** Find $R_{AB}$ in the network in Fig. P2.62.

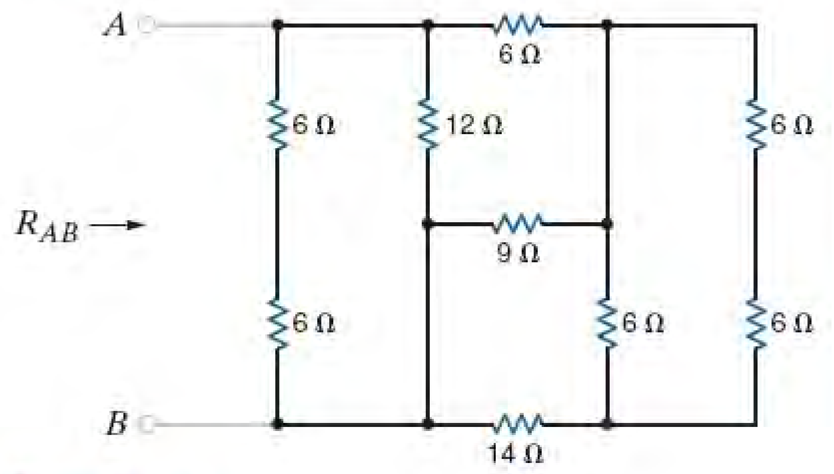
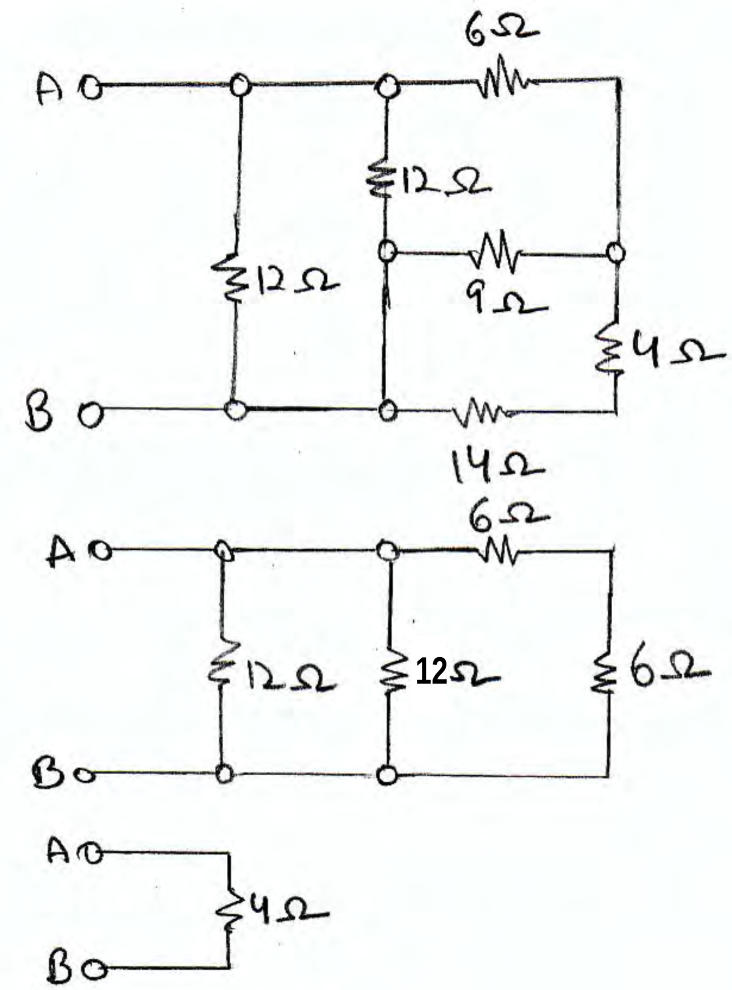



**Figure P2.62**

## SOLUTION:



**2.63** Find the equivalent resistance $R_{eq}$ in the network in Fig. P2.63.

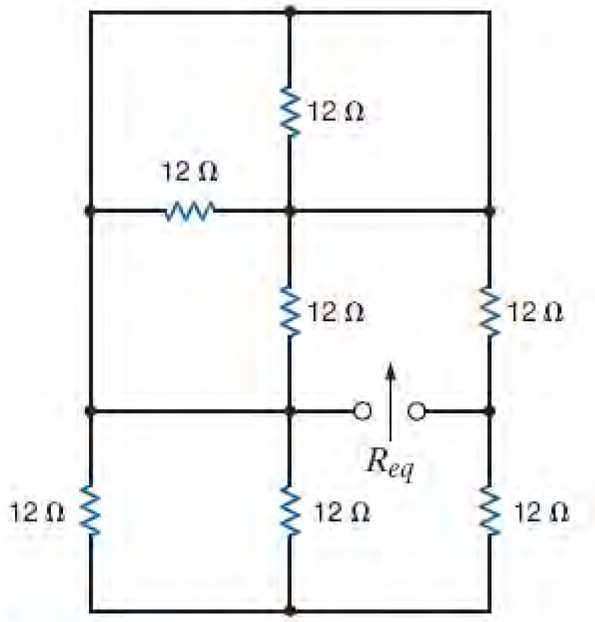
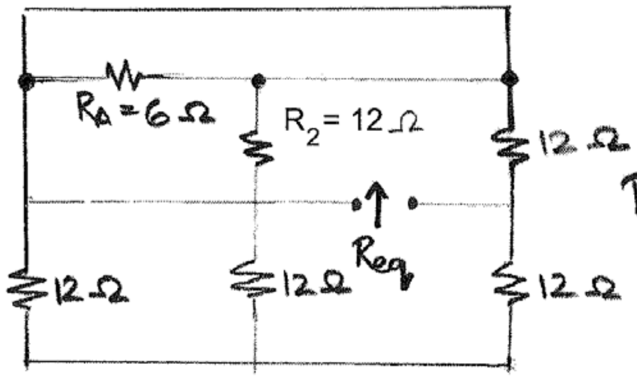


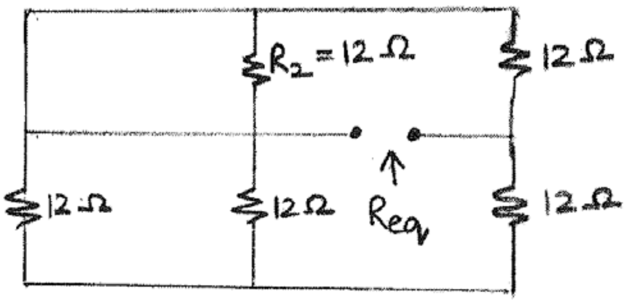

Figure P2.63

## SOLUTION:

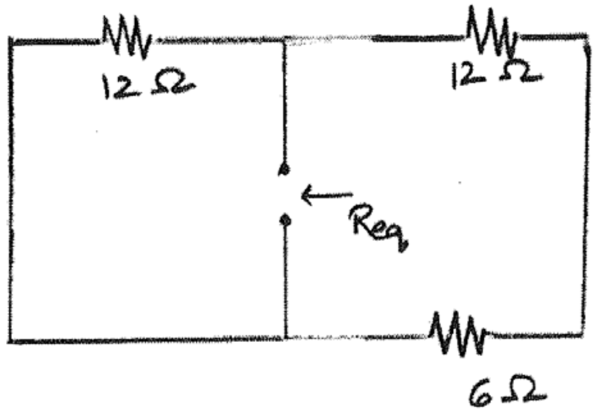
$$R_A = R_1 \| R_3 = 6\ \Omega$$




$R_A$ is shorted.




$R_2$ is shorted.




$$R_{eq} = 12 \parallel 18$$

$$R_{eq} = 7.2\ \Omega$$

**2.64** Find the equivalent resistance looking in at terminals a-b in the circuit in Fig. P2.64.

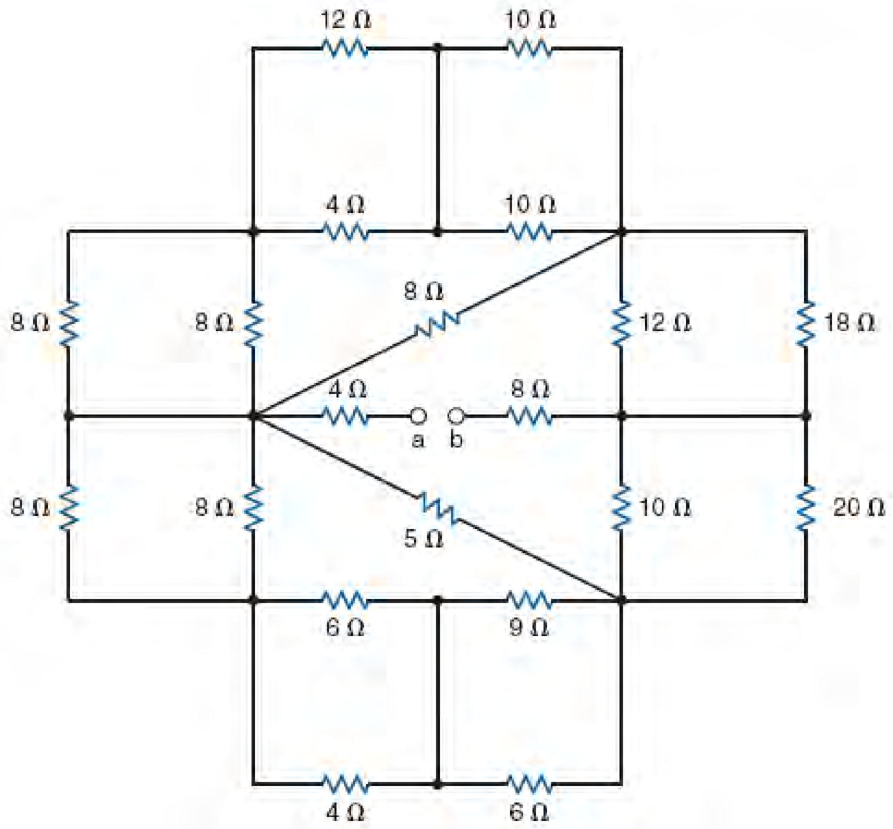
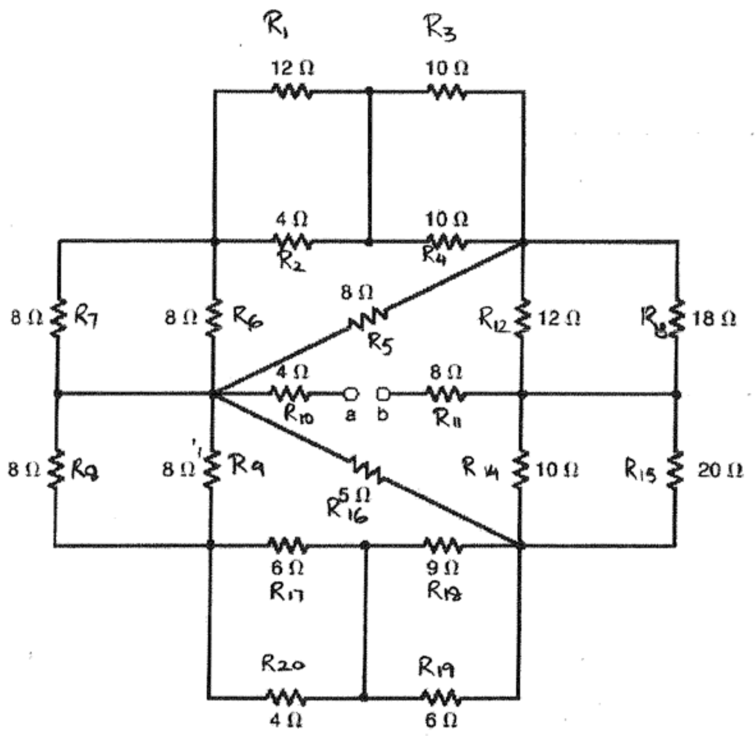



Figure P2.64

## SOLUTION:



$R_a = R_1 \| R_2 = 12\|4 = 3\,\Omega$

$R_b = R_3 \| R_4 = 10\|10 = 5\,\Omega$

$R_c = R_7 \| R_6 = 8\|8 = 4\,\Omega$

$R_d = R_{12} \| R_{13} = 12\|18 = 7.2\,\Omega$

$R_e = R_8 \| R_9 = 8\|8 = 4\,\Omega$

$R_f = R_{14} \| R_{15} = 10\|20 = 6.67\,\Omega$

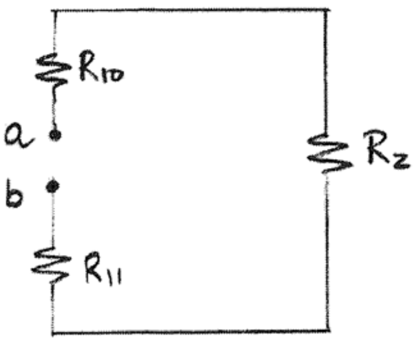
$R_g = R_{17} \| R_{20} = 6\|4 = 2.4\,\Omega$

$R_h = R_{18} \| R_{19} = 9\|6 = 3.6\,\Omega$

$R_z = (R_x + R_d) \| (R_y + R_f)$

$R_z = (4.8 + 7.2) \| (3.33 + 6.67)$

$R_z = 12 \| 10 = 5.45\,\Omega$



$$R_{ab} = R_{10} + R_{11} + R_2 = 4 + 8 + 5.45$$

$$R_{ab} = 17.45\ \Omega$$

**2.65** Given the resistor configuration shown in Fig. P2.65, find the equivalent resistance between the following sets of terminals: (1) a and b, (2) b and c, (3) a and c, (4) d and e, (5) a and e, (6) c and d, (7) a and d, (8) c and e, (9) b and d, and (10) b and e.

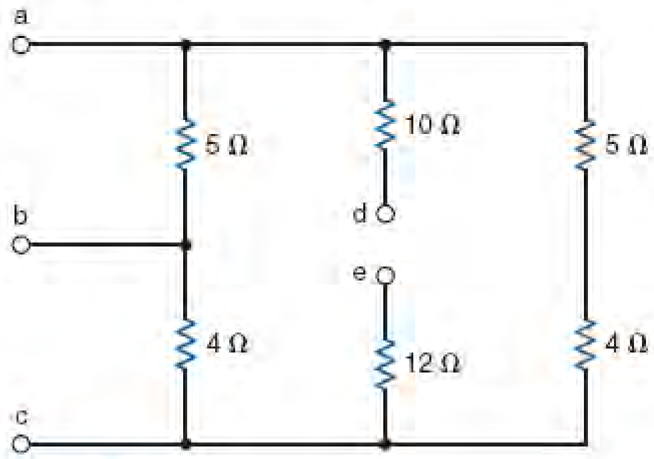
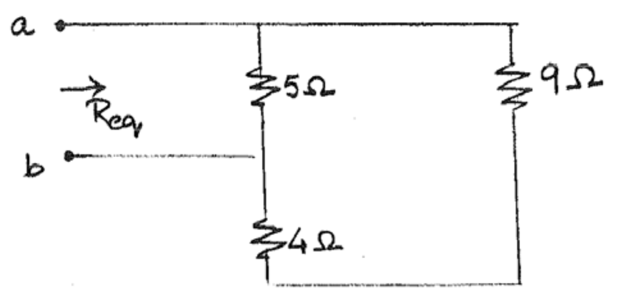



**Figure P2.65**

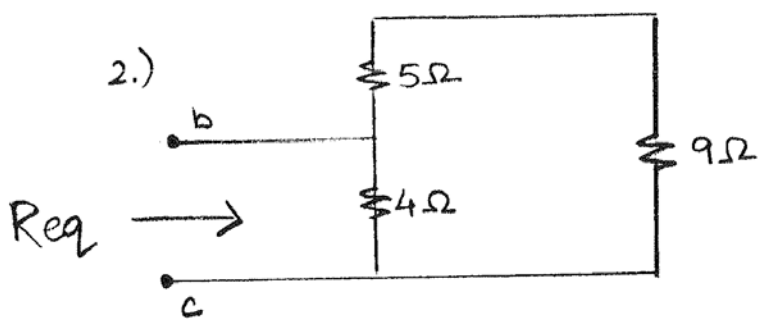
**SOLUTION:**

1.)



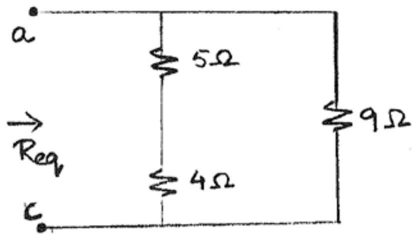

$R_{eq} = (9+4) \| 5 = 3.61\ \Omega$

2.)



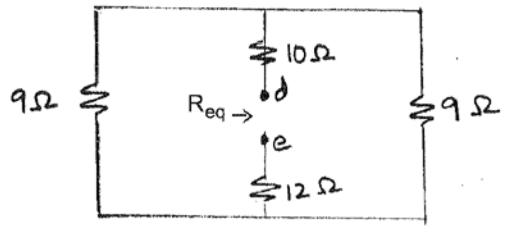

$R_{eq} = 14 \| 14 = 3.11\ \Omega$

3.)



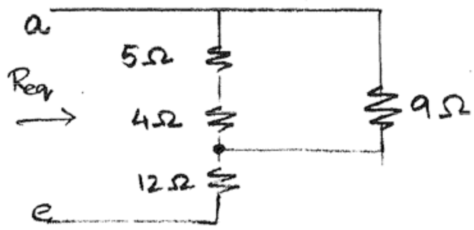

$R_{eq} = 9 \| 9 = 4.5\ \Omega$

4.)



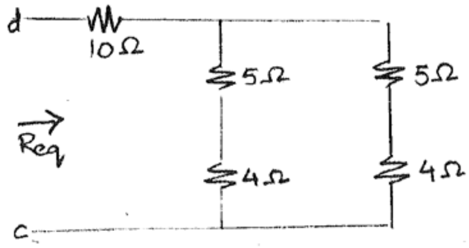

$R_{eq} = (9 \| 9) + 10 + 12 = 26.5\ \Omega$

5.)




$R_{eq} = [9 \| (5+4)] + 12 = (9 \| 9) + 12 = 16.5\ \Omega$

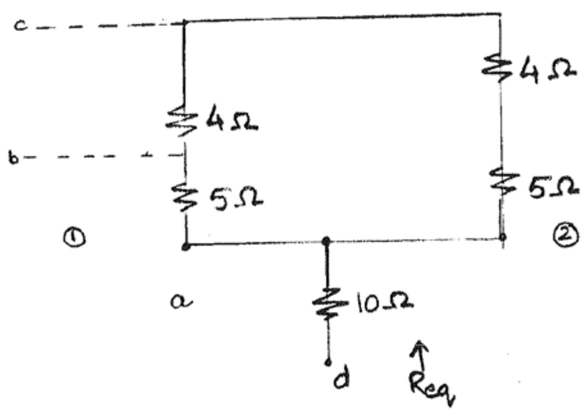
6.)

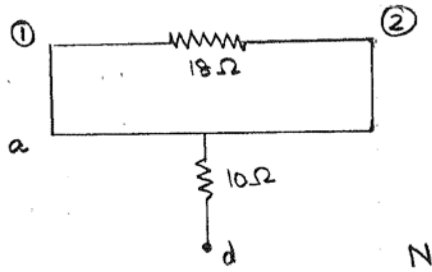



$R_{eq} = (9 \| 9) + 10$

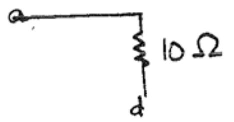
$R_{eq} = 14.5\ \Omega$

7.)



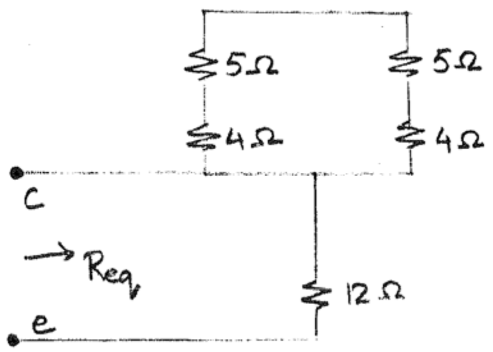




Node ① and ② are shorted.



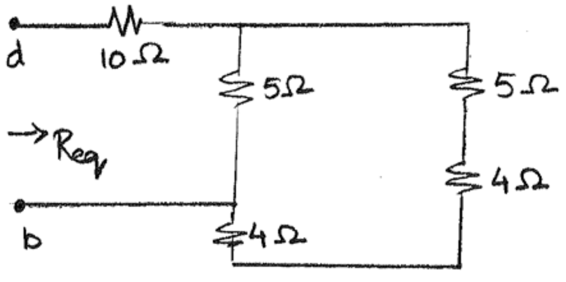

$= R_{eq} = 10\,\Omega$

8.)



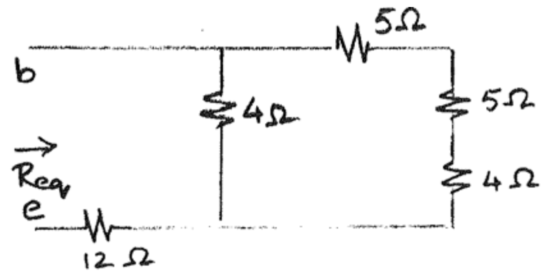

$R_{eq} = 12\,\Omega$

9.)




$R_{eq} = (13 \| 5) + 10 = 13.61\,\Omega$

10.)




$$R_{eq} = (14 \| 4) + 12$$

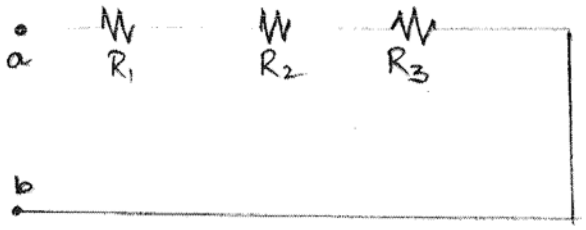
$$R_{eq} = \frac{4(14)}{4+14} + 12$$

$$R_{eq} = 15.11\,\Omega$$

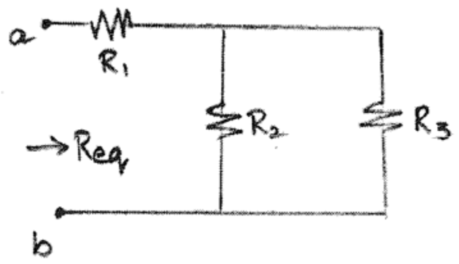
**2.66** Seventeen possible equivalent resistance values may be obtained using three resistors. Determine the seventeen different values if you are given resistors with standard values: 47 Ω, 33 Ω, and 15 Ω.

## SOLUTION:

$R_1 = 47\Omega$, $R_2 = 33\Omega$, and $R_3 = 15\Omega$

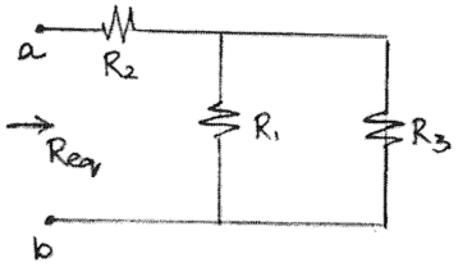



$$R_{eq} = R_1 + R_2 + R_3 = 95\Omega$$



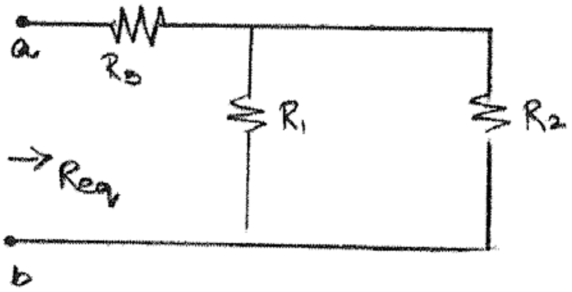

$$R_{eq} = R_1 + (R_2 \| R_3) = 47 + \frac{33(15)}{33+15}$$

$$R_{eq} = 57.31\ \Omega$$



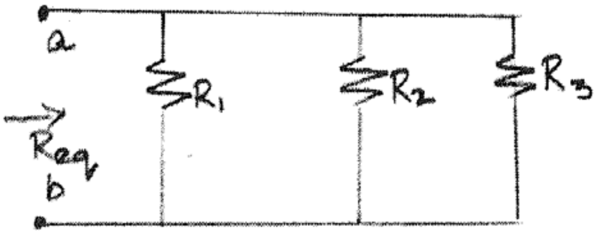

$$R_{eq} = R_2 + (R_1 \| R_3) = 33 + \frac{47(15)}{47+15}$$

$$R_{eq} = 44.37\Omega$$




$$R_{eq} = R_3 + (R_1 \| R_2) = 15 + \frac{47(33)}{47+33}$$

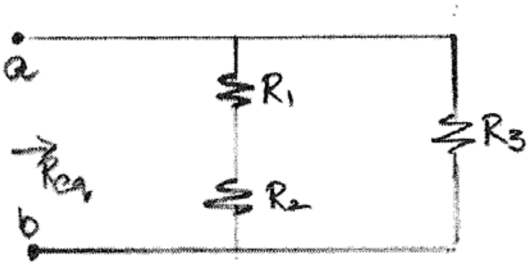
$$R_{eq} = 34.39\ \Omega$$



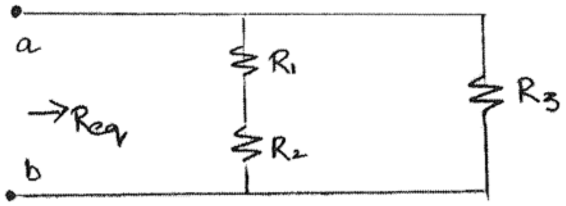

$$R_{eq} = R_1 \| R_2 \| R_3 = 47 \| 33 \| 15$$

$$R_{eq} = \frac{47(33)}{47+33} \| 15$$

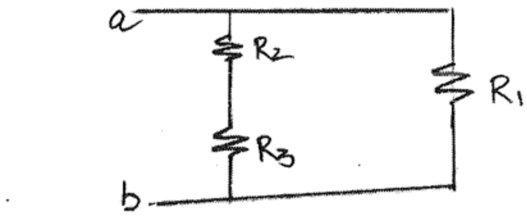
$$R_{eq} = 19.39 \| 15 = 8.46\ \Omega$$




$$R_{eq} = (R_1 + R_2) \| R_3 = 80 \| 15 = 12.63\ \Omega$$

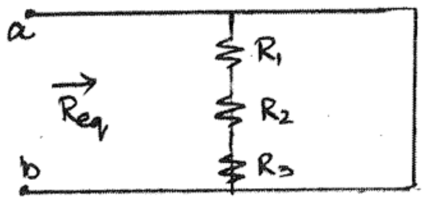



$$R_{eq} = (R_1 + R_3) \| R_2 = 62 \| 33 = 21.54\,\Omega$$



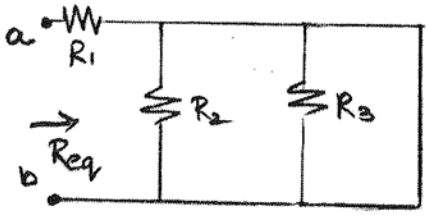

$$R_{eq} = (R_2 + R_3) \| R_1 = 48 \| 47$$

$$R_{eq} = 23.75\,\Omega$$



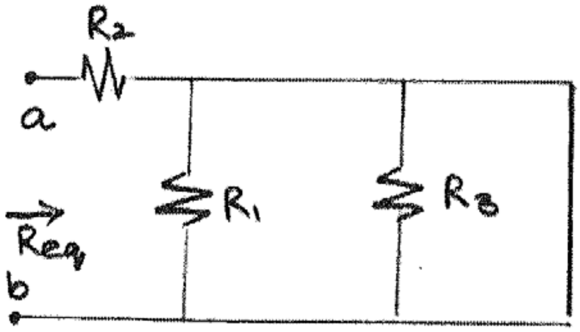

$$R_{eq} = (R_1 + R_2 + R_3) \| 0$$

$$R_{eq} = 0\,\Omega$$



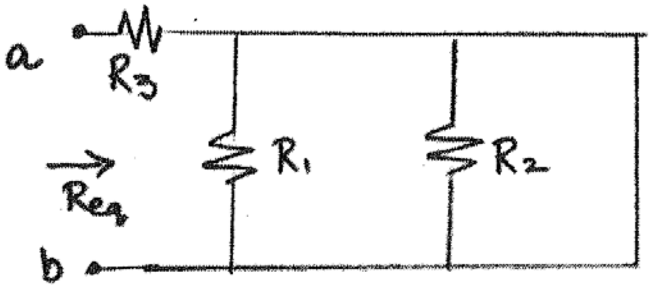

$$R_{eq} = R_1 + (R_2 \| R_3 \| 0)$$

$$R_{eq} = R_1 = 47\,\Omega$$



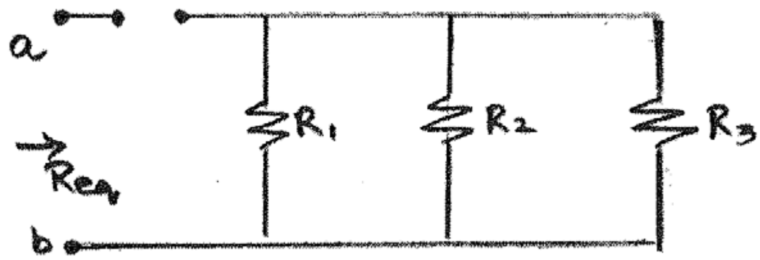

$$R_{eq} = R_2 + (R_1 \| R_3 \| 0)$$

$$R_{eq} = R_2 = 33\,\Omega$$

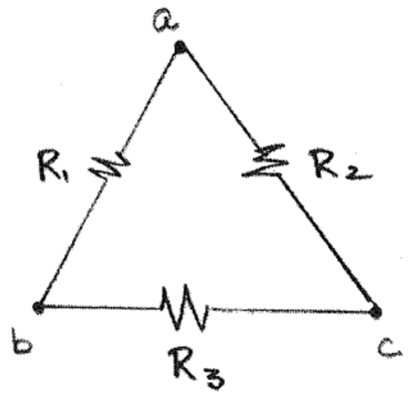



$$R_{eq} = R_3 + (R_1 \| R_2 \| 0)$$

$$R_{eq} = R_3 = 15\,\Omega$$



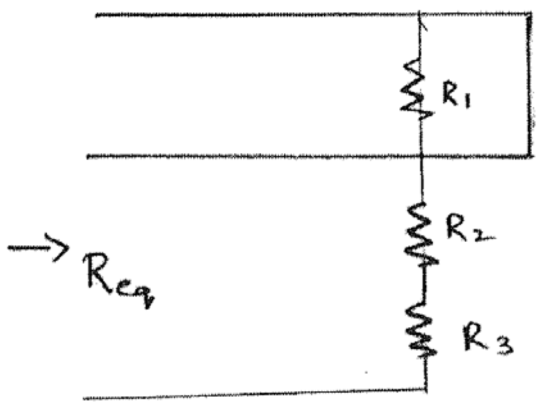

$$R_{eq} = \infty$$




$$R_{ab} = \frac{R_2 (R_1 + R_3)}{R_2 + R_1 + R_3} = \frac{33(47+15)}{33+47+15} = 21.53\,\Omega$$

$$R_{bc} = \frac{R_3 (R_1 + R_2)}{R_3 + R_1 + R_2} = \frac{15\,(47+33)}{15+47+33} = 12.63\,\Omega$$

$$R_{ca} = \frac{R_1 (R_2 + R_3)}{R_1 + R_2 + R_3} = \frac{47(33+15)}{47+33+15} = 23.75\,\Omega$$




$$(R_1 \| 0) + R_2 + R_3$$

$$= R_2 + R_3$$

**2.67** Find $I_1$ and $V_0$ in the circuit in Fig. P2.67.

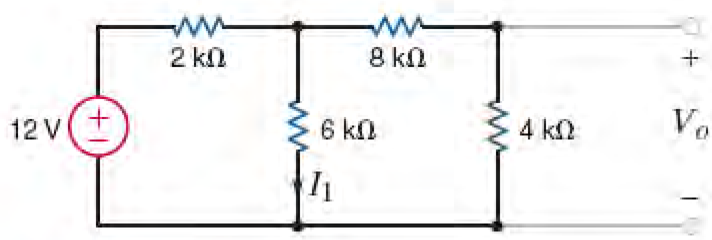
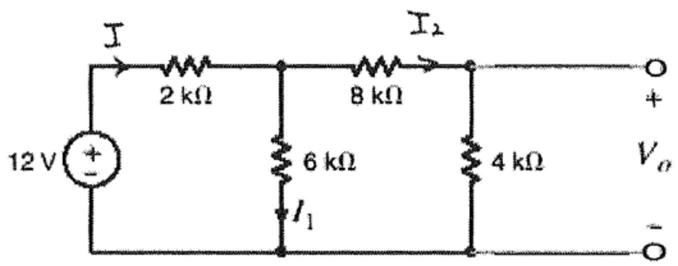


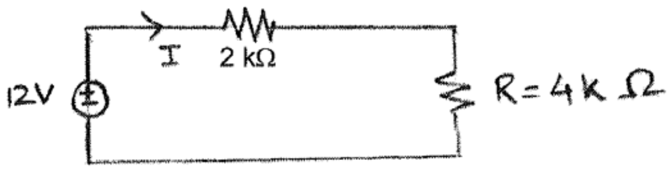

Figure P2.67

## SOLUTION:




$R = 12K \| 6K$

$R = 4K\ \Omega$




$$I = \frac{12}{2K+4K}$$

$$I = 2mA$$

$$I_1 = \left(\frac{8K+4K}{8K+4K+6K}\right)(2m)$$

$$I_1 = 1.33\ mA$$

KCL:

$$I = I_1 + I_2$$

$$I_2 = 2m - 1.33m$$

$$I_2 = 0.667\,mA$$

$$V_0 = I_2(4k)$$

$$V_0 = 0.667(4k)$$

$$V_0 = 2.67V$$

**2.68** Find $I_1$ and $V_0$ in the circuit in Fig. P2.68.

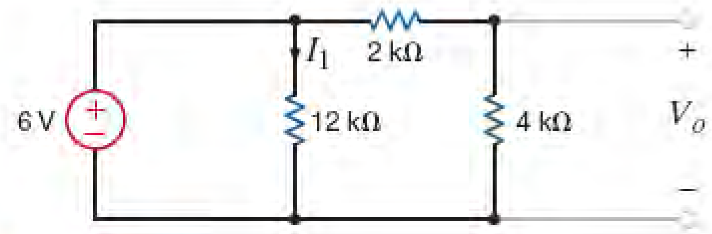
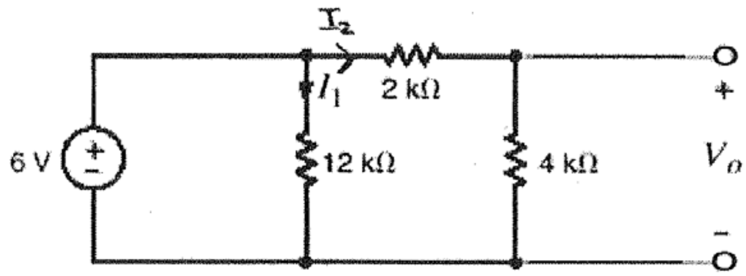



Figure P2.68

## SOLUTION:




$$I_1 = \frac{6}{2K} = 0.5\,mA$$

$$I_2 = \frac{6}{2k+4k} = 1\,mA$$

$$V_o = I_2(4K) = 1m(4k)$$

$$V_0 = 4\,V$$

**2.69** Find $V_{ab}$ and $V_{dc}$ in the circuit in Fig. P2.69.

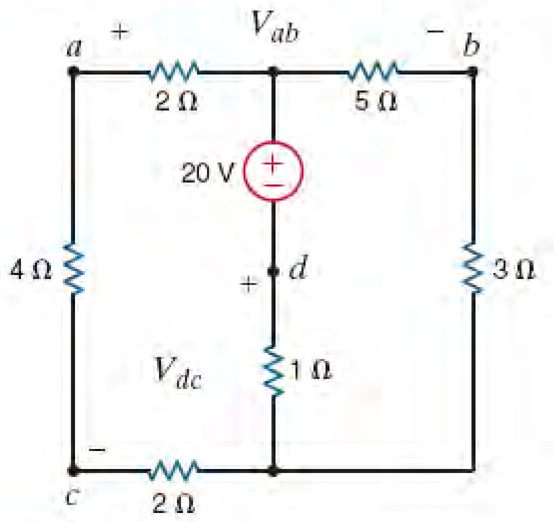
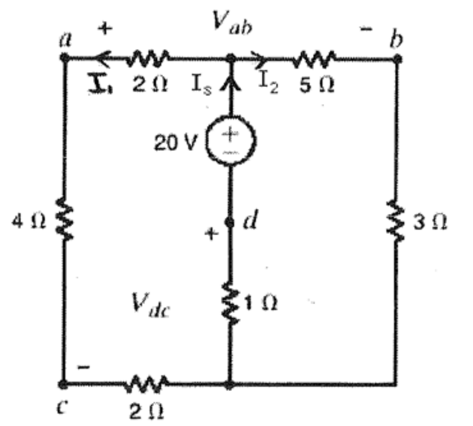
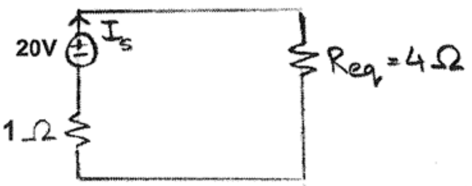



**Figure P2.69**

## SOLUTION:




$R_{eq} = 8 \| 8$

$R_{eq} = 4\Omega$

$$I_s = \frac{20}{5} = 4A$$

$$I_1 = \left(\frac{5+3}{5+3+2+4+2}\right)(4) = 2A$$

$$I_2 = \left(\frac{2+4+2}{2+4+2+5+3}\right)(4) = 2A$$

KVL:

$$V_{ab} + 2I_1 = 5I_2$$

$$V_{ab} = 5I_2 - 2I_1$$

$$V_{ab} = 5(2) - 2(2)$$

$$V_{ab} = 6V$$

KVL:

$$V_{dc} + 2I_1 + I_s(1) = 0$$

$$V_{dc} = -2(2) - 4(1)$$

$$V_{dc} = -8V$$

**2.70** Find $V_1$ and $I_A$ in the network in Fig. P2.70.

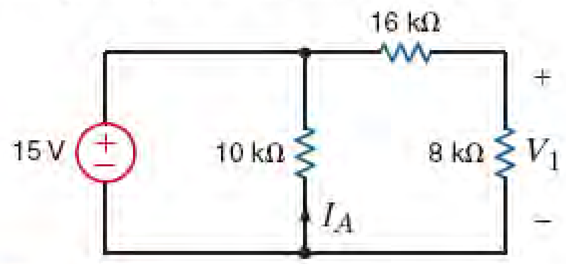
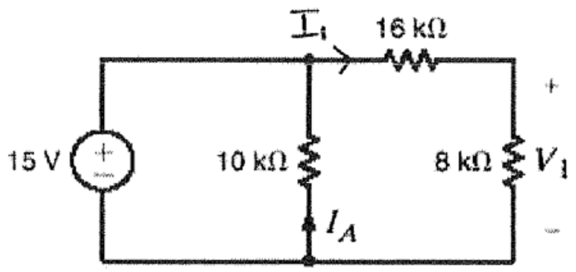



Figure P2.70

## SOLUTION:




$$I_A = -\frac{15}{10K}$$

$$I_A = -1.5mA$$

$$I_1 = \frac{15}{16K+8K}$$

$$I_1 = 0.625\ mA$$

$$V_1 = I_1(8K) = (0.625m)(8K)$$

$$V_1 = 5V$$

**2.71** Find $I_o$ in the network in Fig. P2.71.

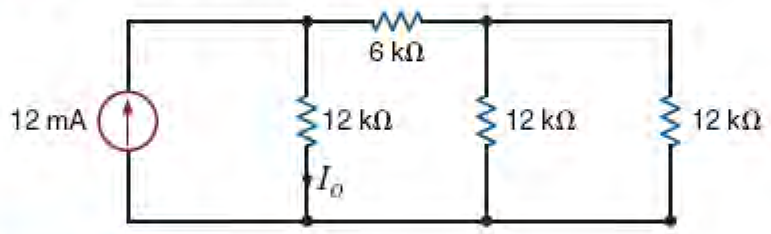
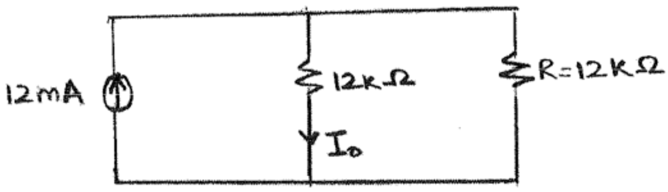



**Figure P2.71**

## SOLUTION:




$R = (12k \| 12k) + 6k$

$R = 12K\,\Omega$

$$I_o = \left(\frac{12k}{12k+12k}\right)(12m) = 6mA$$

**2.72** Determine $I_o$ in the circuit in Fig. P2.72.

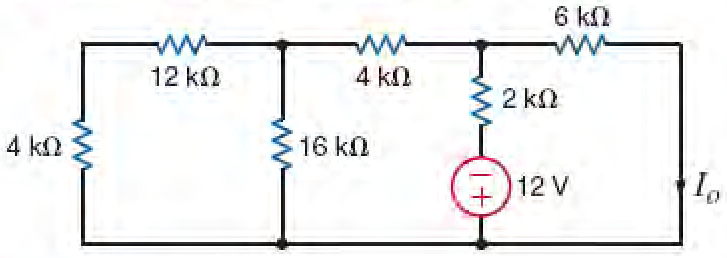
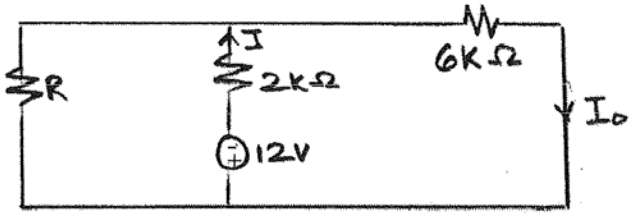


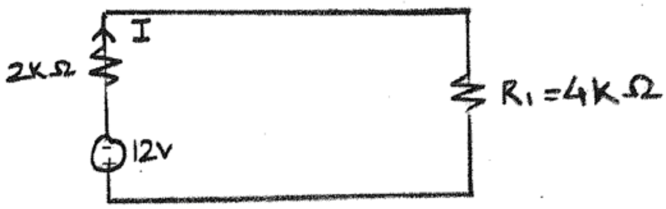

Figure P2.72

## SOLUTION:




$$R = \left[(4K + 12K) \| 16K\right] + 4K$$

$$R = 8K + 4K = 12K\,\Omega$$




$$R_1 = 12K \| 6K$$

$$R_1 = 4K\Omega$$

$$I = \frac{-12}{2K + 4K} = -2mA$$

Current divison:

$$I_o = \left(\frac{12k}{12k + 6k}\right)(-2m)$$

$$I_o = -1.33\,mA$$

**2.73** Determine $V_o$ in the network in Fig. P2.73.

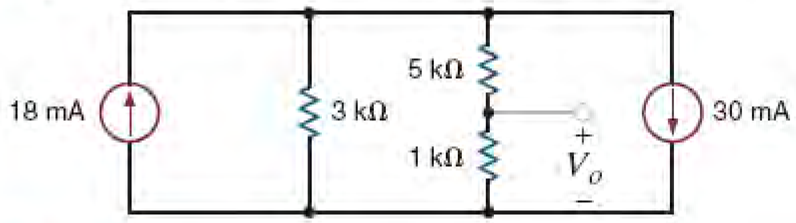
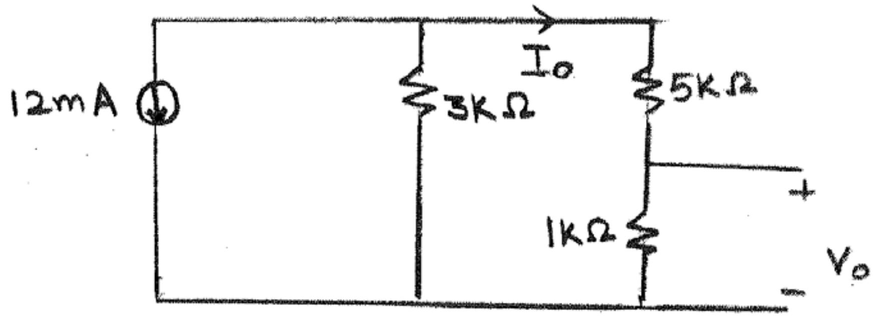



**Figure P2.73**

**SOLUTION:**




$$I_o = \left(\frac{3k}{3k+5k+1k}\right)(-12m)$$

$$I_o = -4mA$$

$$V_o = I_o(1k) = (-4m)(1k)$$

$$V_o = -4V$$

**2.74** Calculate $V_{ab}$ in Fig. P2.74.

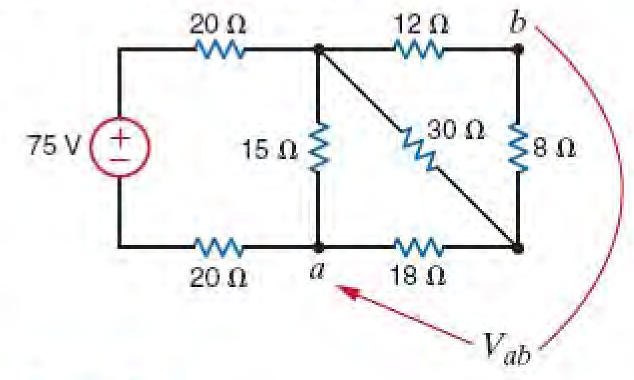
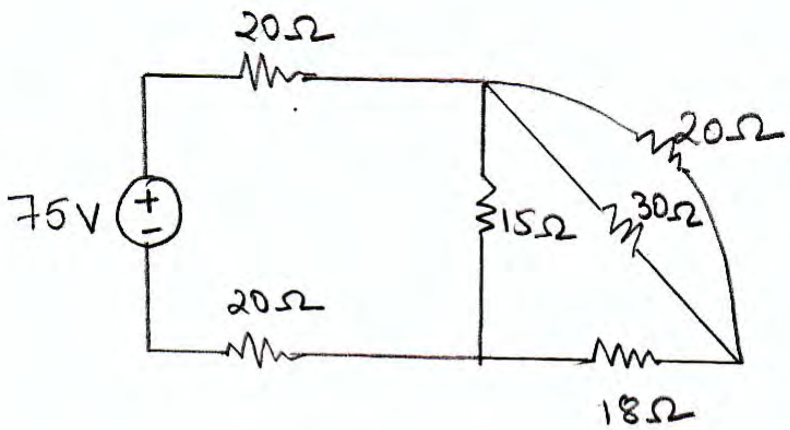
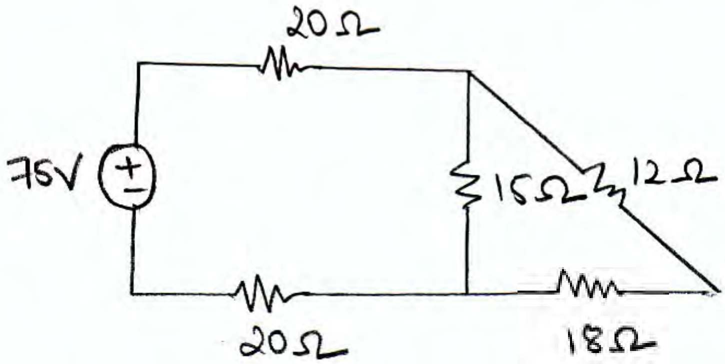
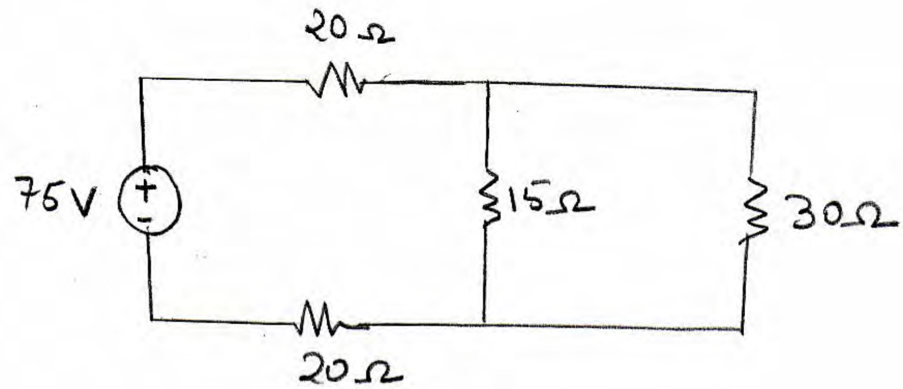


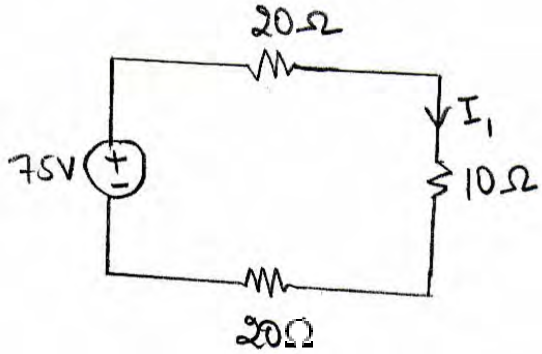

Figure P2.74

**SOLUTION:**

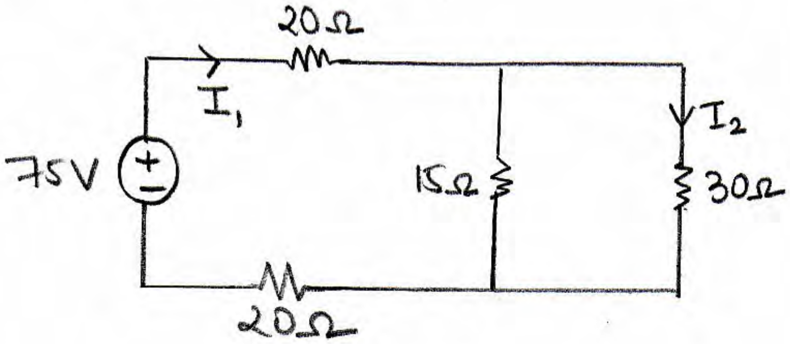




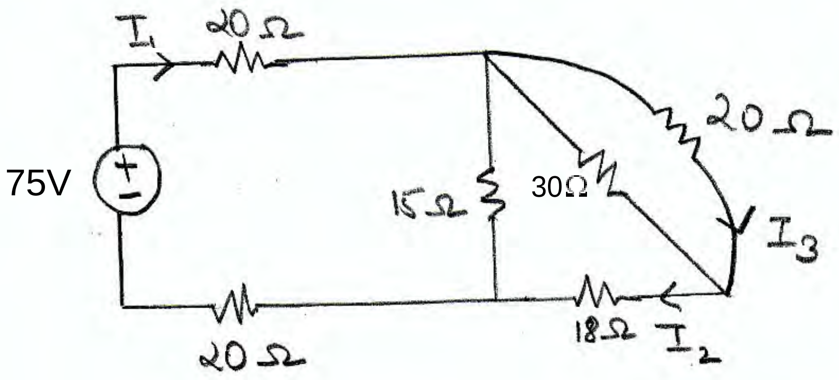




$$I_1 = \frac{75}{20+10+20} = 1.5A$$

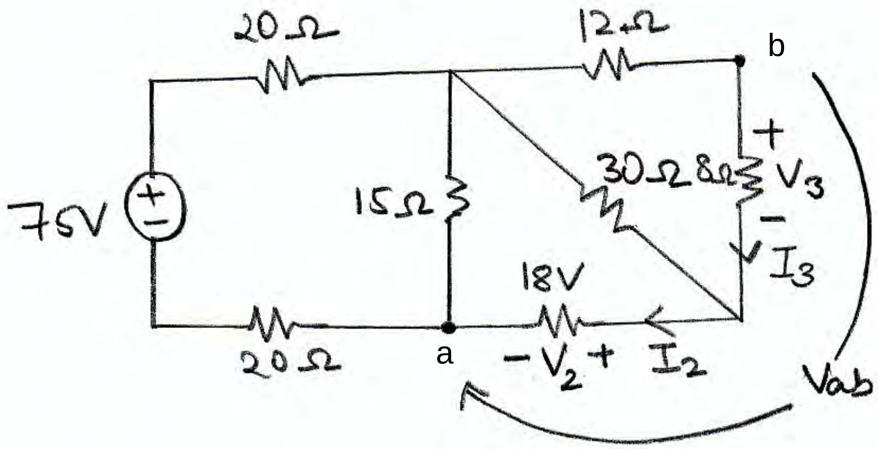



$$I_2 = 1.5\left(\frac{15}{15+30}\right)$$

$$= 0.5A$$




$$I_3 = 0.5\left(\frac{30}{30+20}\right) = 0.3A$$




$$V_3 = 8I_3 = 8(0.3) = 2.4V$$

$$V_2 = 18\,I_2 = 18(0.5) = 9V$$

$$V_{ab} = -V_2 - V_3 = -9 - 2.4 = -11.4V$$

**2.75** Calculate $V_{AB}$ in Fig. P2.75.

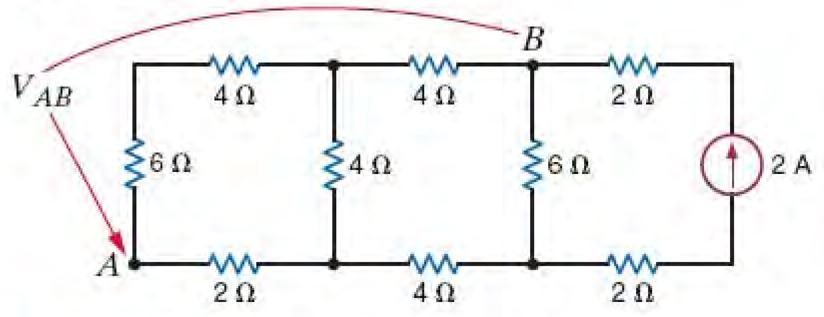
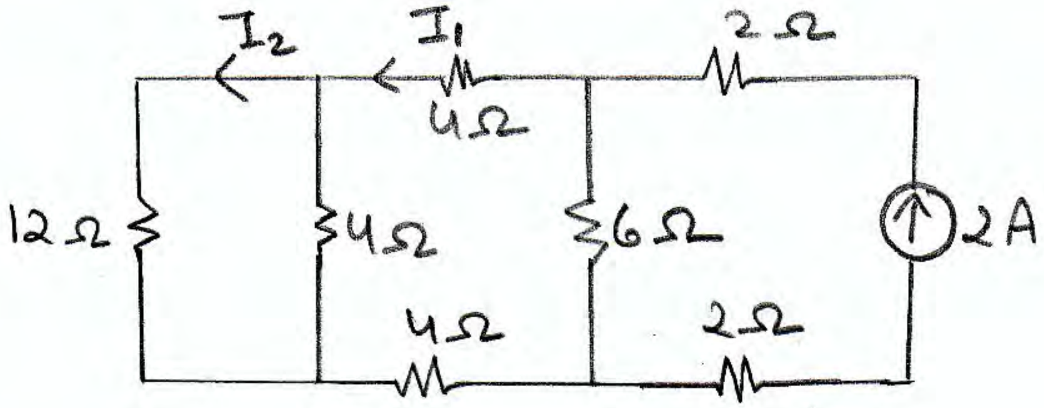
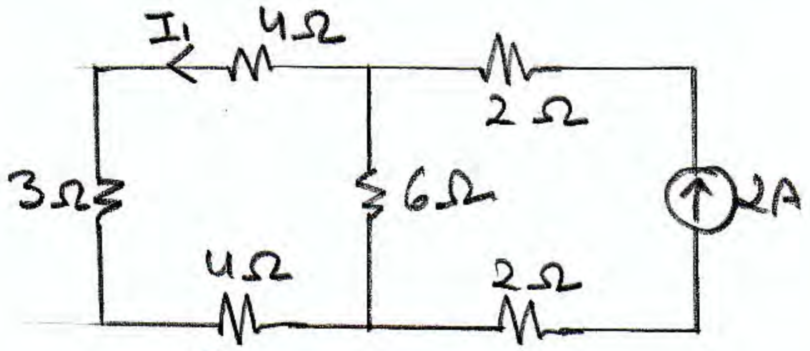
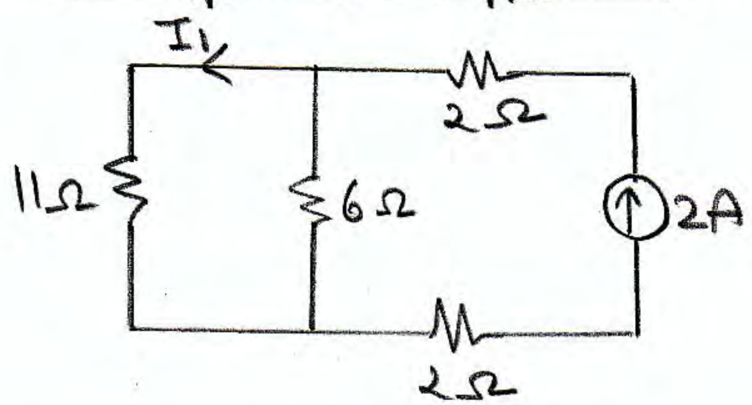



**Figure P2.75**

**SOLUTION:**

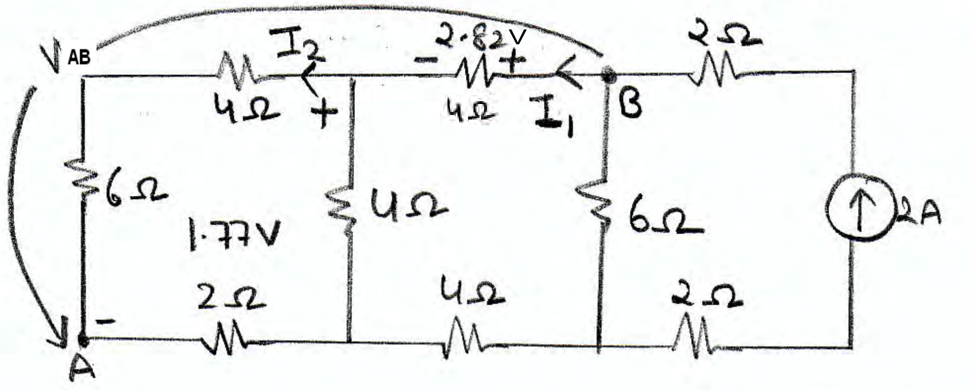



$$I_1 = 2\left(\frac{6}{6+11}\right) = 0.706 \text{ A}$$

$$I_2 = I_1\left(\frac{4}{4+12}\right) = 0.706\left(\frac{4}{4+12}\right) = 0.177A$$




$$V_{AB} = -1.77 - 2.82 = \underline{-4.59V}$$

**2.76** Calculate $V_{ab}$ and $V_1$ in Fig. P2.76.

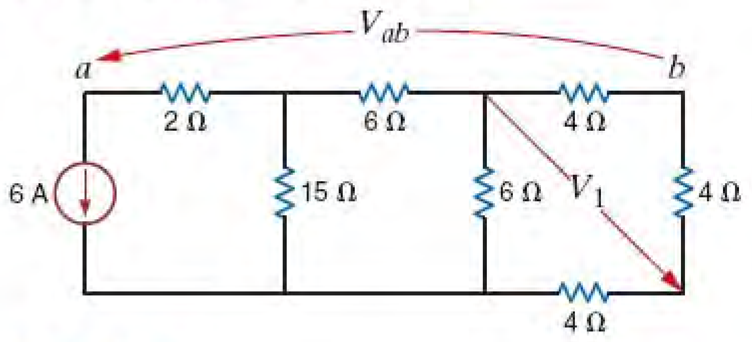
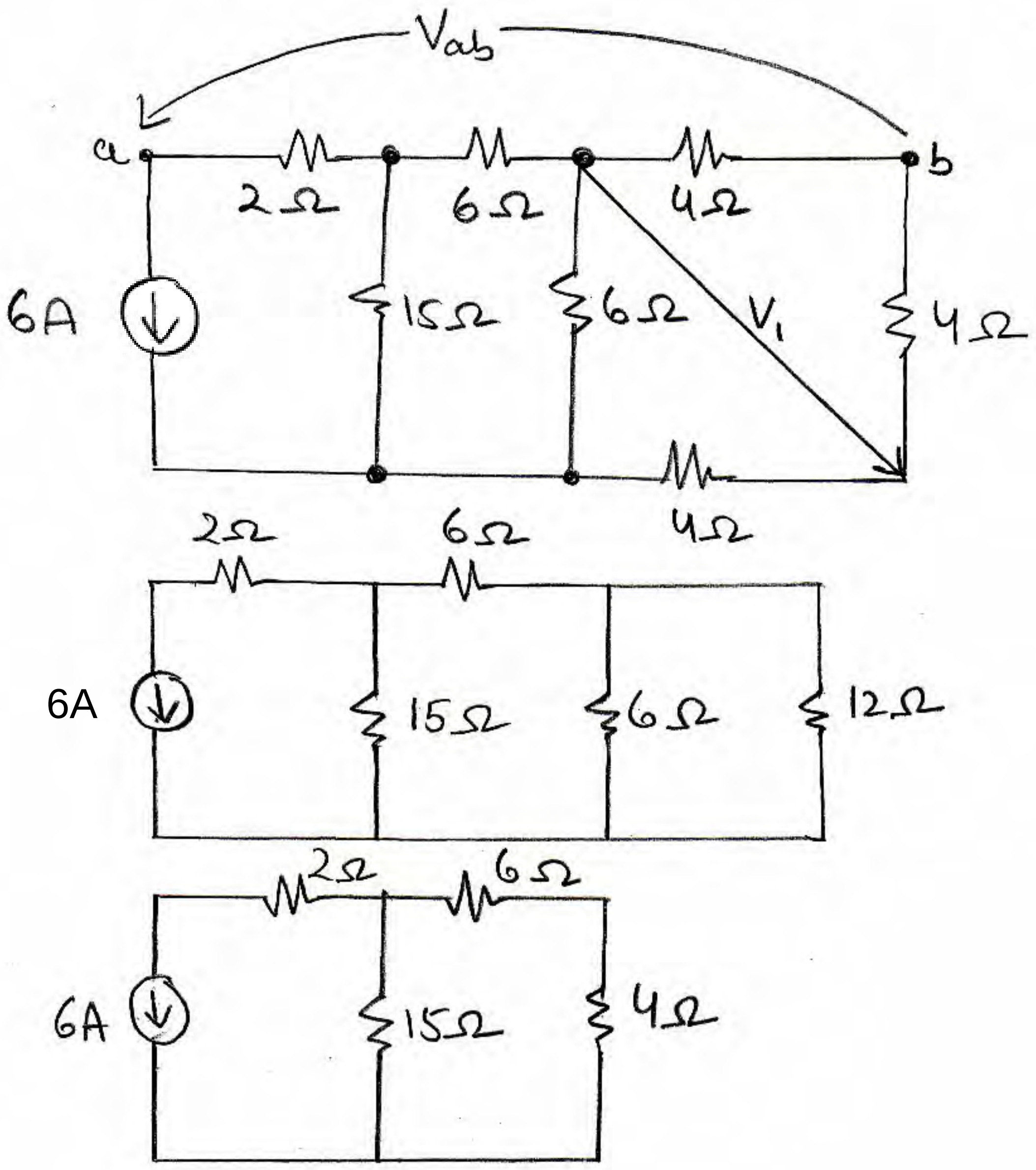
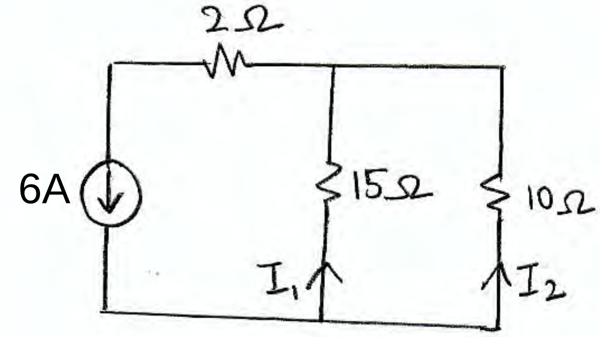


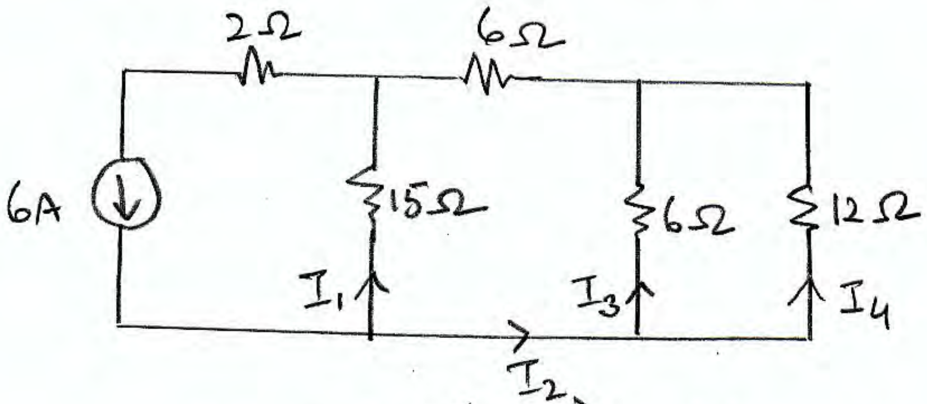

Figure P2.76

**SOLUTION:**



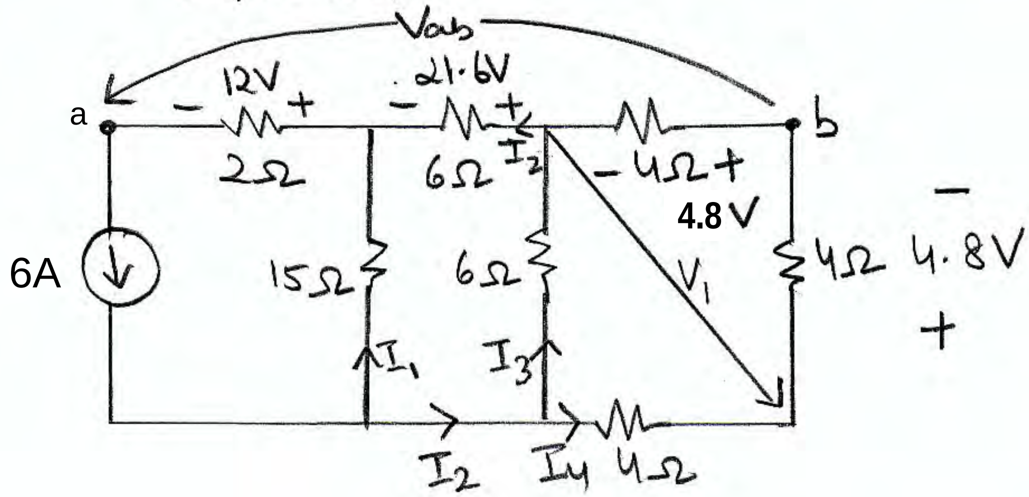



$$I_1 = 6\left(\frac{10}{10+15}\right)$$
$$= 2.4A$$
$$I_2 = 3.6A$$




$$I_3 = 3.6\left(\frac{12}{12+6}\right) = 2.4A$$

$$I_4 = 1.2A$$



$$V_1 = 4.8 + 4.8 = \underline{9.6\,V}$$

$$V_{ab} = -12 - 21.6 - 4.8 = \underline{-38.4\,V}$$

**2.77** Calculate $V_{AB}$ in Fig. P2.77.

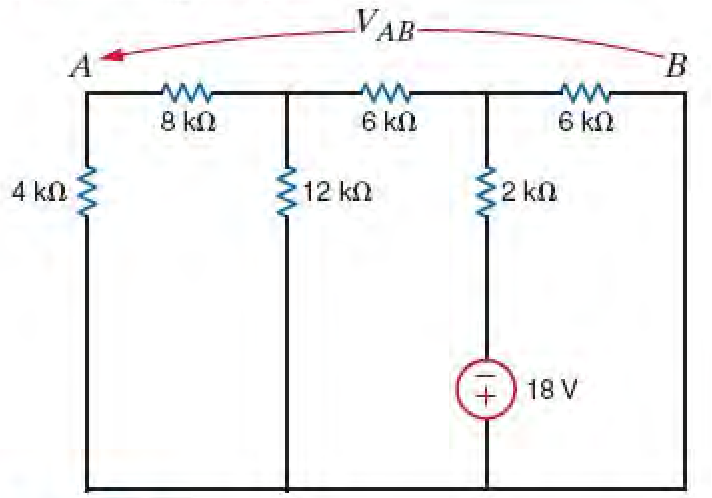
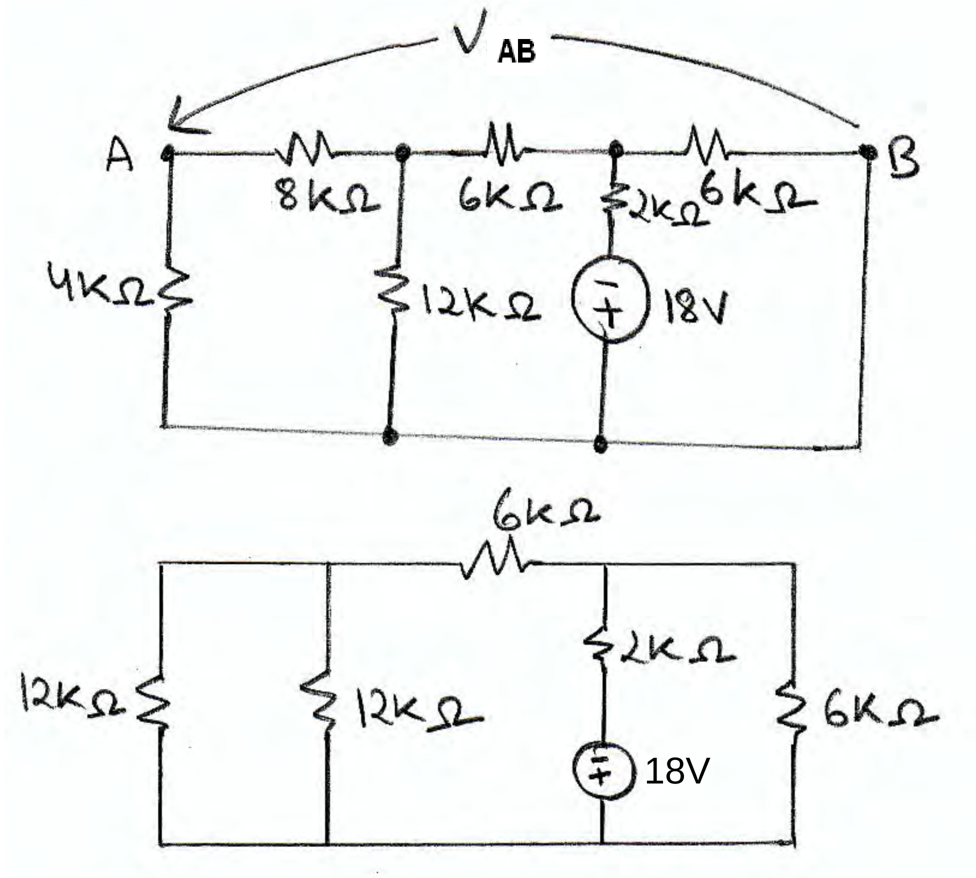
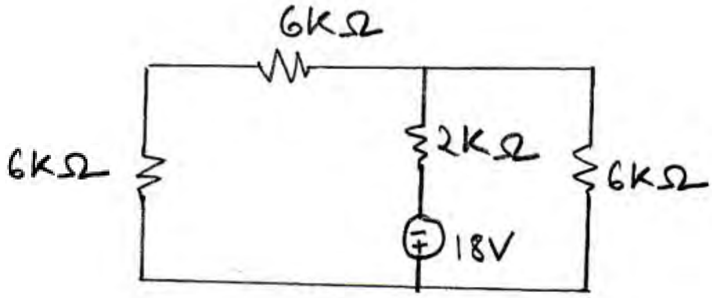
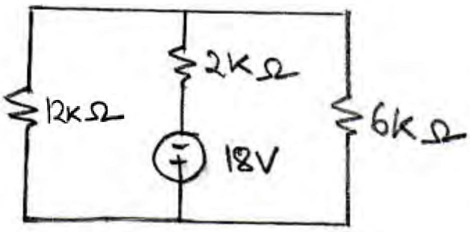


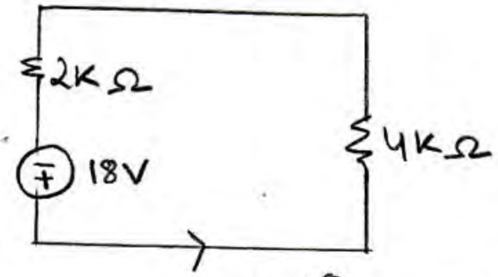

Figure P2.77

## SOLUTION:

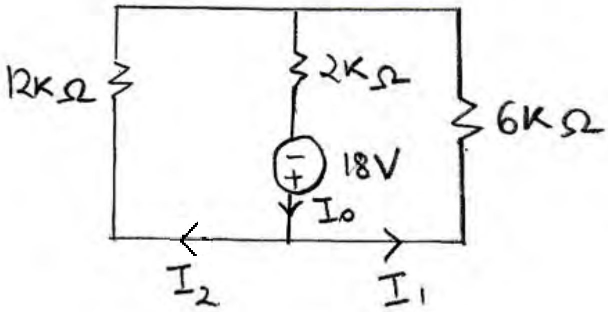




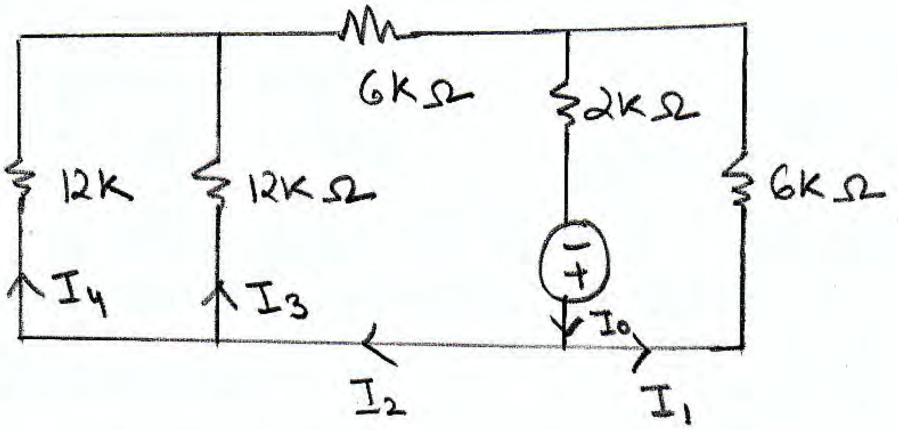

$$I_o = \frac{18}{4K + 2K} = 3mA$$



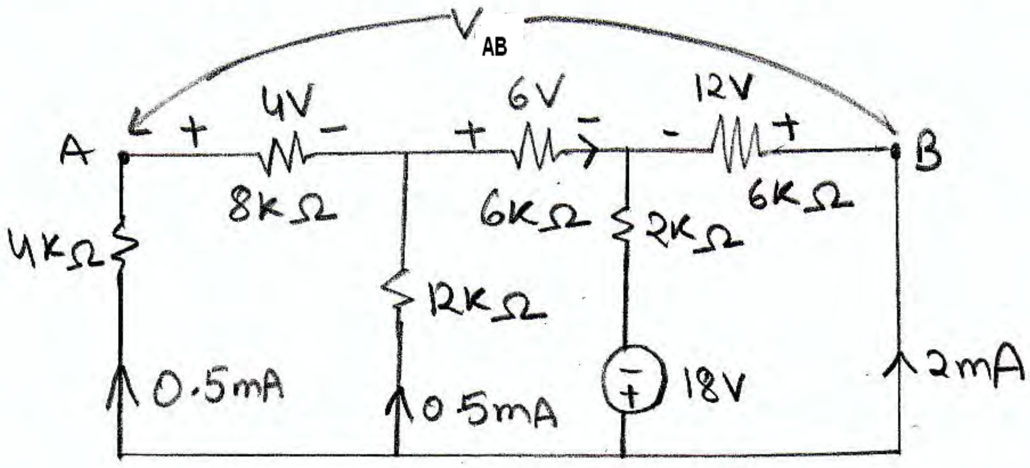

$$I_1 = 3m\left(\frac{12K}{12K + 6K}\right)$$

$$= 2mA$$

$$I_2 = 1mA$$




$$I_3 = I_4 = \frac{1}{2} I_2 = 0.5\,mA$$




$$V_{AB} = 4+6-12 = \underline{-2V}$$

**2.78** Calculate $V_{AB}$ and $I_1$ in Fig. P2.78.

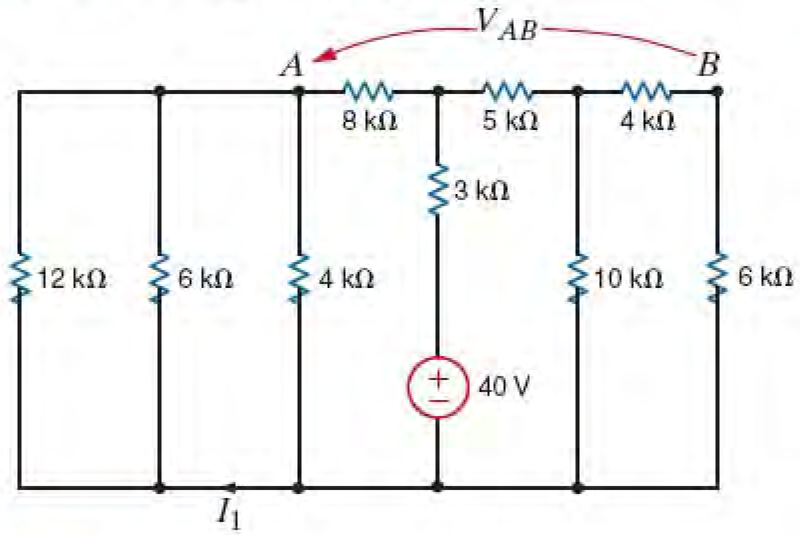
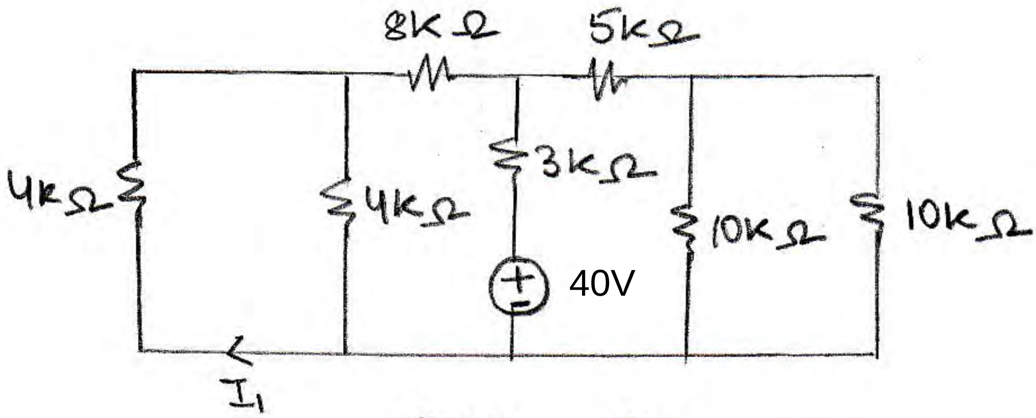
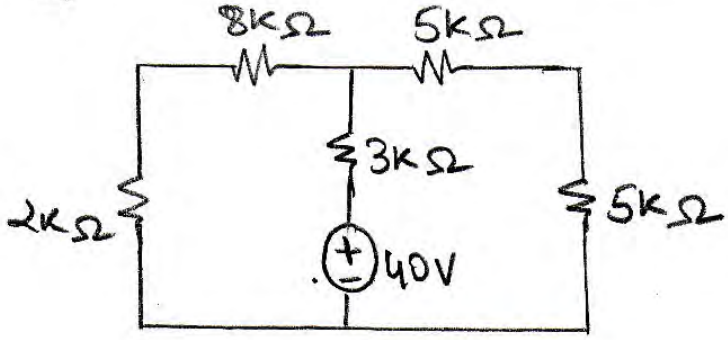
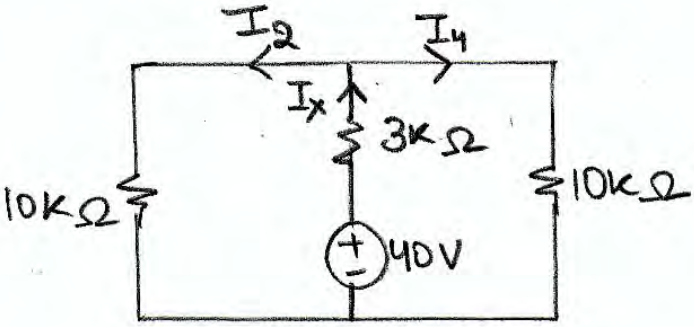



**Figure P2.78**

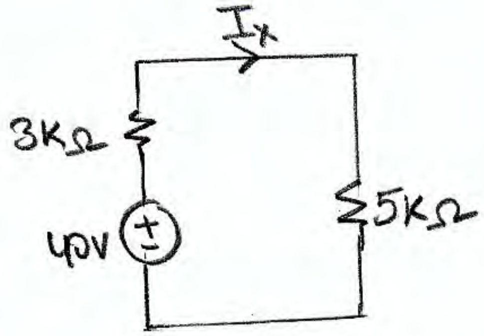
## SOLUTION:



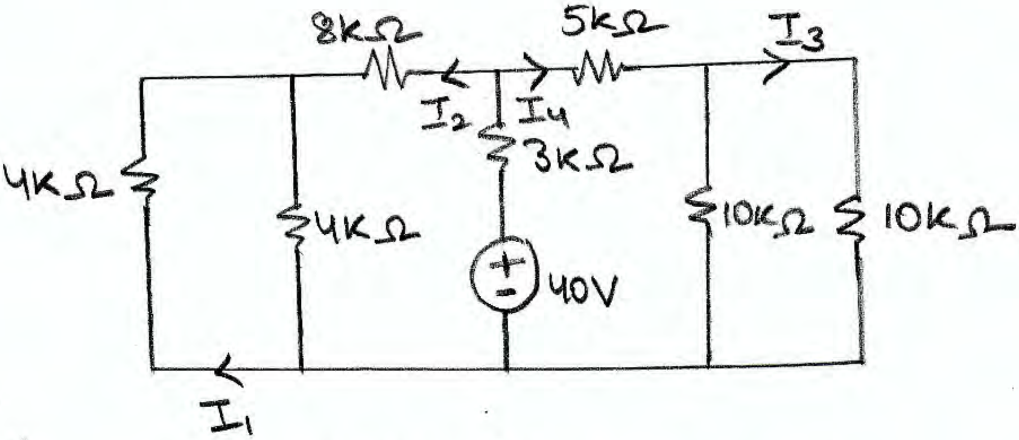



$$I_4 = I_2 = 2.5\,mA$$



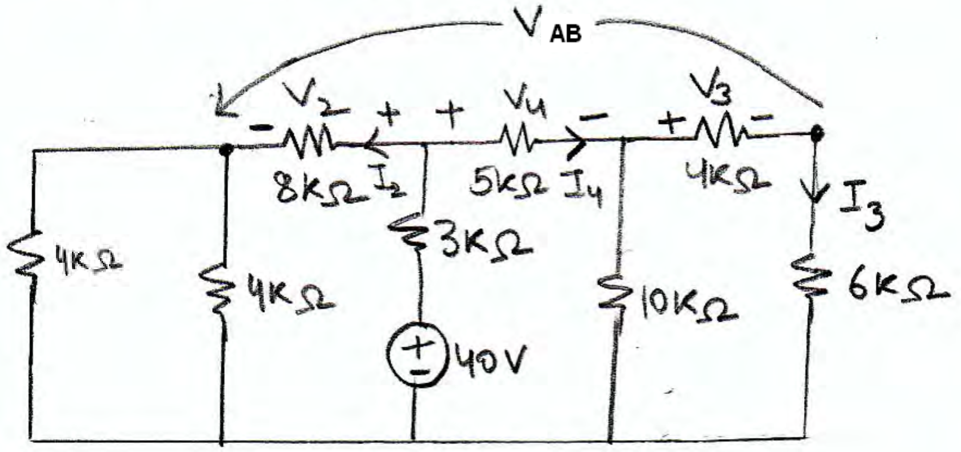

$$I_x = \frac{40}{3K + 5K}$$

$$= 5\,mA$$




$$I_1 = -I_2\left(\frac{4k}{4k + 4k}\right) = \underline{-1.25\,mA}$$

$$I_3 = I_4\left(\frac{10k}{10k+10k}\right) = 1.25\,mA$$




$$V_2 = 8k\ I_2 = (8k)(2.5m) = 20V$$

$$V_4 = 5k\,I_4 = (5k)(2.5m) = 12.5V$$

$$V_3 = 4k\,I_3 = (4k)(1.25m) = 5V$$

$$V_{AB} = -V_2 + V_4 + V_3$$

$$= -20 + 12.5 + 5 = \underline{-2.5V}$$

**2.79** Calculate $V_{AB}$ and $I_1$ in Fig. P2.79.

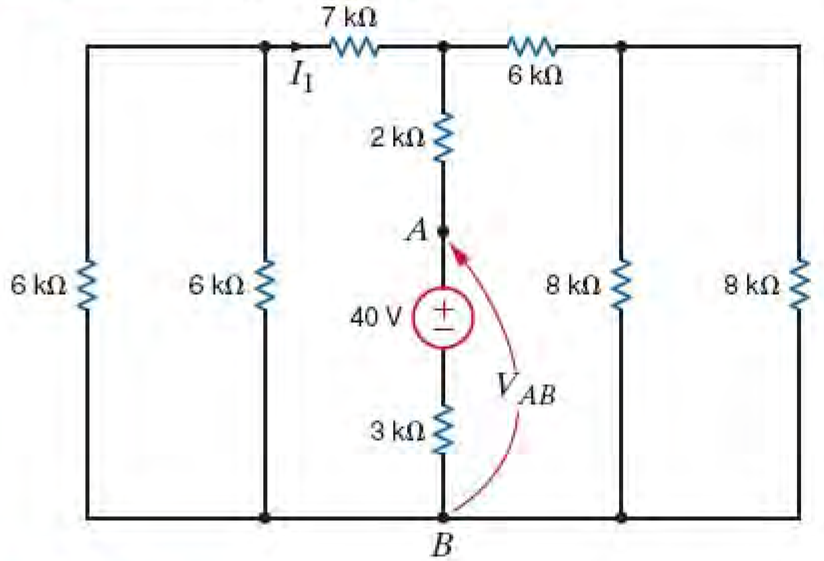
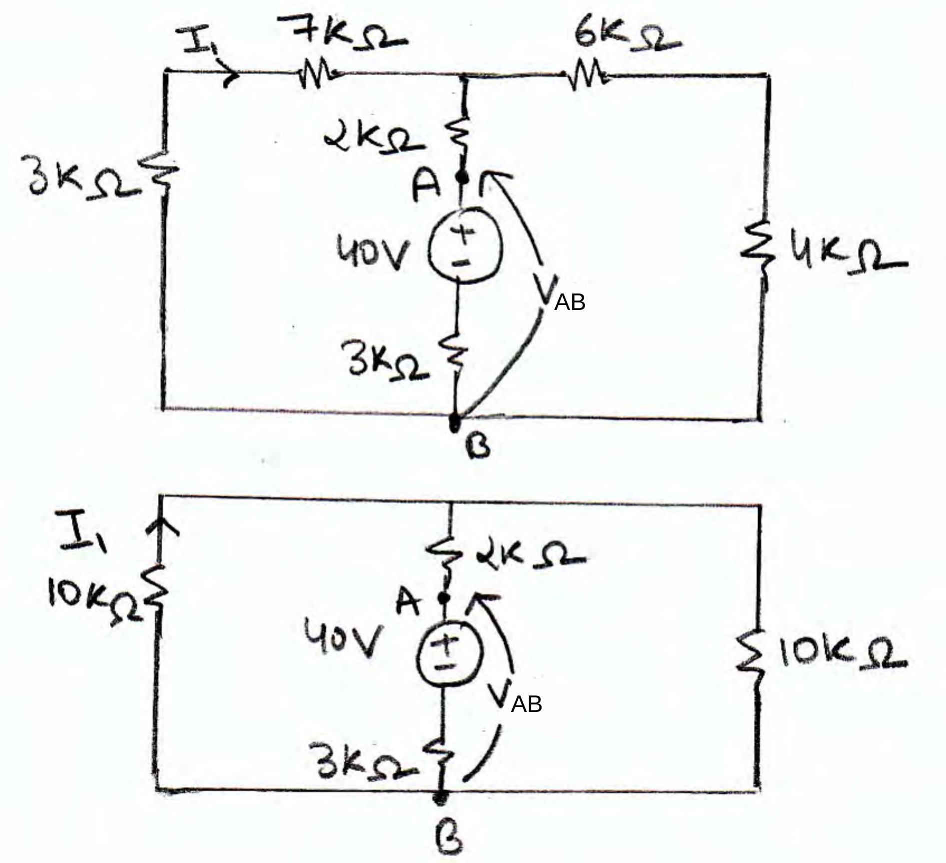
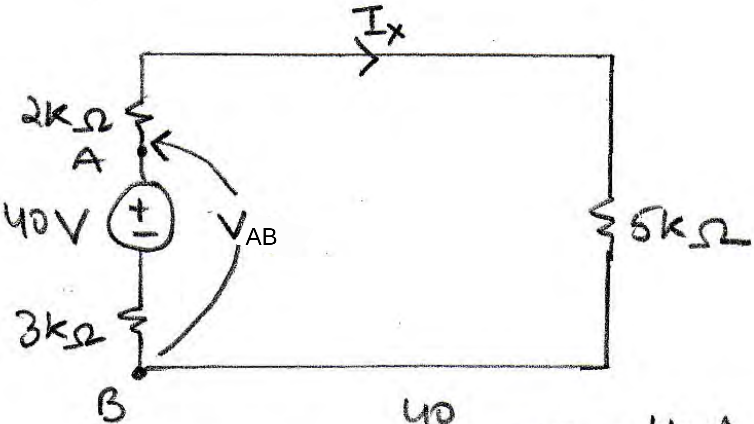



Figure P2.79

## SOLUTION:

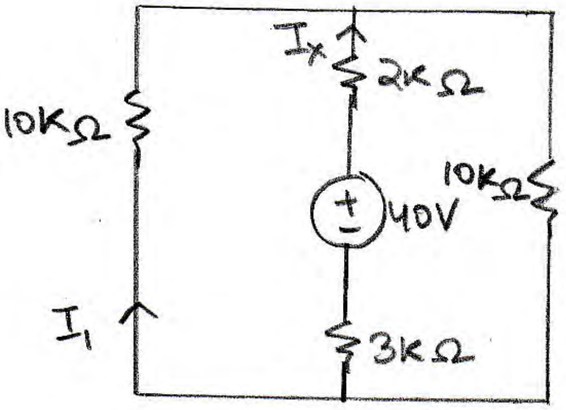





$$I_x = \frac{40}{2k+3k+5k} = 4mA$$

$$V_{AB} = 2kI_x + 5kI_x = 7kI_x$$

$$V_{AB} = (7k)(4m) = \underline{28V}$$




$$I_1 = -I_x\left(\frac{10k}{10k+10k}\right)$$

$$I_1 = \frac{-1}{2} I_x$$

$$I_1 = \frac{-1}{2}(4mA)$$

$$I_1 = -2mA$$

**2.80** Find $V_{ab}$ in Fig. P2.80.

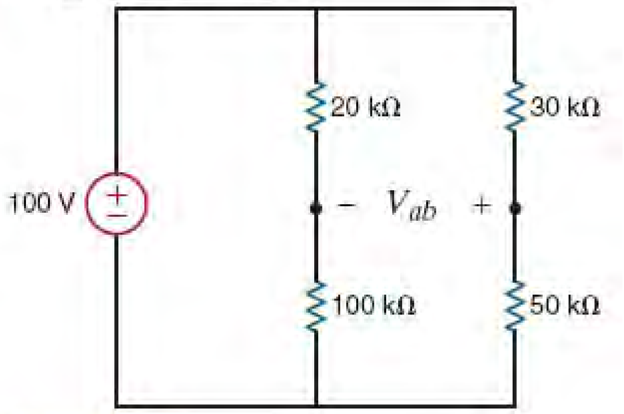
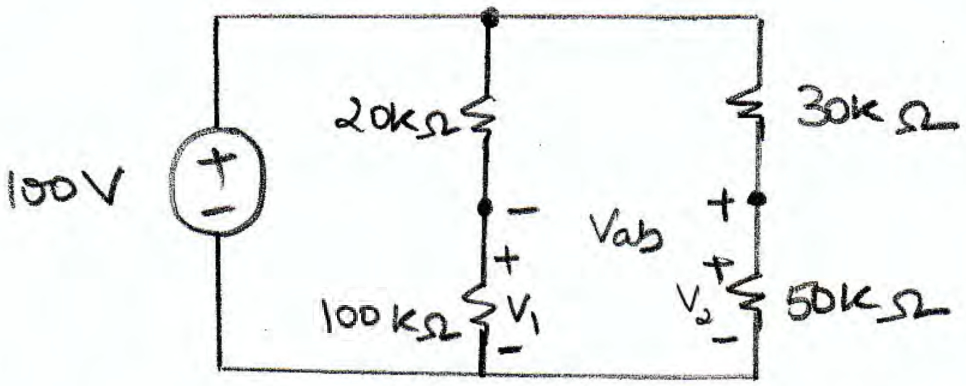



Figure P2.80

## SOLUTION:




$$V_1 = 100\left(\frac{100k}{20k+100k}\right) = 83.33V$$

$$V_2 = 100\left(\frac{50k}{50k+30k}\right) = 62.5V$$

$$V_{ab} = V_2 - V_1 = 62.5 - 83.3$$

$$= -20.8V$$

**2.81** If $V_o = 4$ V in the network in Fig. P2.81, find $V_S$.

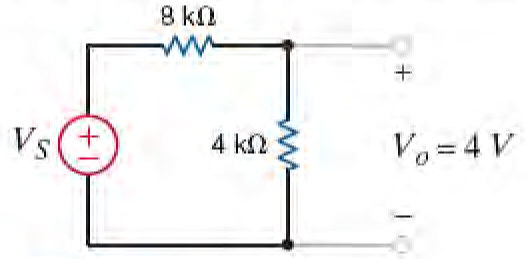



Figure P2.81

## SOLUTION:

$$V_o = \left(\frac{4K}{4K+8K}\right) V_S$$

$$V_S = \frac{4}{\left(\frac{4K}{4K+8K}\right)} = 12\text{V}$$

**2.82** If $I_o = 5$ mA in the circuit in Fig. P2.82, find $I_S$.

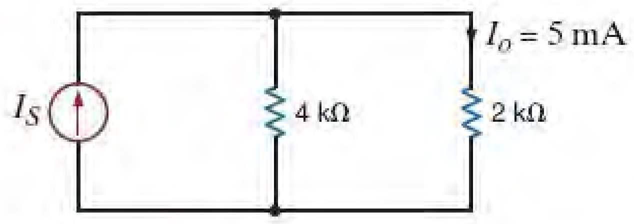
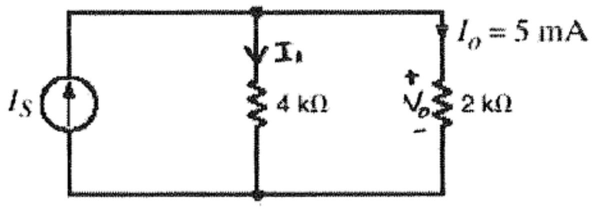



Figure P2.82

**SOLUTION:**




$$V_o = I_o(2K) = 5m(2K) = 10V$$

$$I_1 = \frac{10}{4K}$$

$$I_1 = 2.5mA$$

KCL:

$$I_s = I_1 + I_o$$

$$I_s = 2.5m + 5m$$

$$I_s = 7.5mA$$

**2.83** If $I_o = 2$ mA in the circuit in Fig. P2.83, find $V_S$.

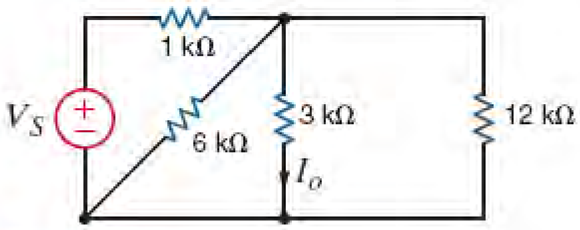
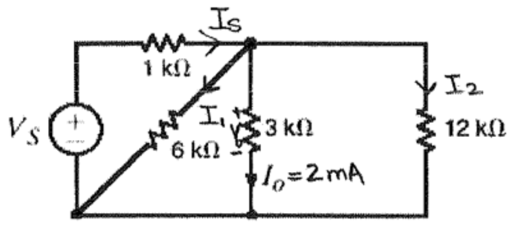



Figure P2.83

## SOLUTION:




$$V_O = I_o(3K) = 2m(3K) = 6V$$

$$I_1 = \frac{6}{6k} = 1mA$$

$$I_2 = \frac{6}{12k} = 0.5mA$$

KCL:

$$I_S = I_1 + I_o + I_2 = 1m + 2m + 0.5m$$

$$I_s = 3.5mA$$

KVL:

$$V_s = 1K\,I_s + V_o$$

$$V_s = 1K(3.5) + 6$$

$$V_s = 9.5\ V$$

**2.84** Find the value of $V_S$ in the network in Fig. P2.84 such that the power supplied by the current source is 0.

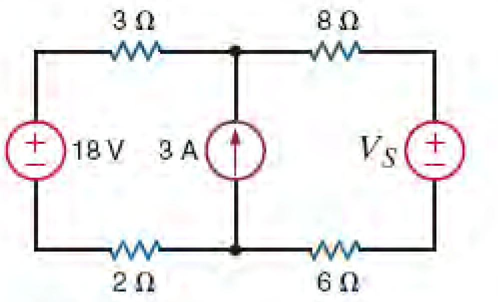
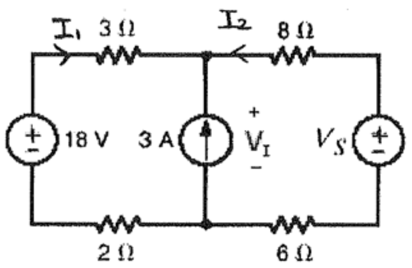



Figure P2.84

**SOLUTION:**




$$P_{Is} = V_I(3) = 0W$$

$$V_I = 0V$$

KVL:

$$18 = 3I_1 + 2I_1 + V_I$$

$$I_1 = \frac{18}{5} A$$

KCL:

$$I_2 = -I_1 - 3$$

$$I_2 = -18/5 - 3$$

$$I_2 = -33/5 A$$

$$V_S = 8I_2 + 6I_2 + V_I$$

$$V_S = 14I_2 = 14\left(-\frac{33}{5}\right)$$

$V_s = -92.4\,V$

**2.85** In the network in Fig. P2.85, $V_o = 6$ V. Find $I_S$.

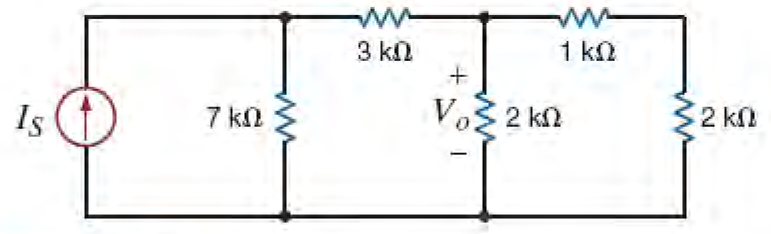
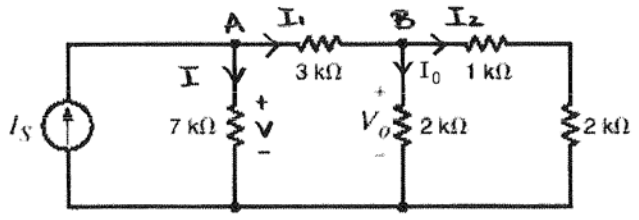



Figure P2.85

**SOLUTION:**




$$I_o = \frac{6}{2k} = 3mA$$

$$I_2 = \frac{6}{1k + 2k} = 2mA$$

KCL at B:

$$I_1 = I_o + I_2 = 3m + 2m = 5mA$$

KVL :

$$V = I_1(3k) + V_o$$

$$V = 5m\,(3k) + 6$$

$$V = 21V$$

$$I = \frac{V}{7k} = \frac{21}{7k} = 3mA$$

KCL at A:

$$I_s = I + I_1$$

$$I_s = 3m + 5m$$

$$I_s = 8mA$$

**2.86** Find the value of $V_1$ in the network in Fig. P2.86 such that $V_a = 0$.

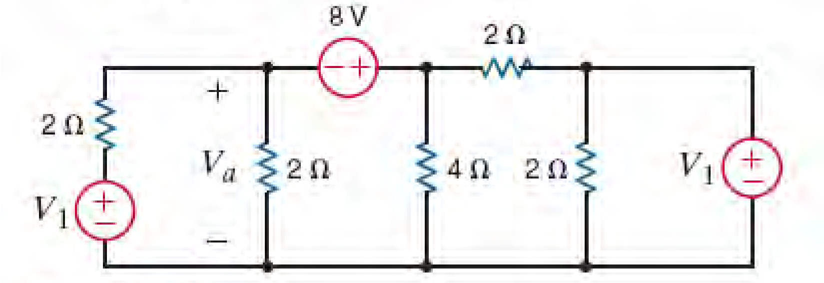
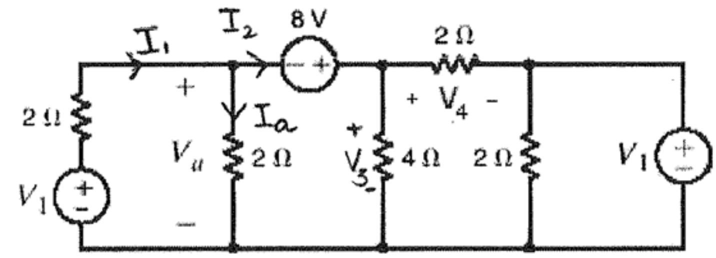



Figure P2.86

## SOLUTION:




$I_1 = I_2$ ; $I_a = 0$ since $V_a = 0$

$I_1 = \frac{V_1}{2}$

KCL:

$$I_2 = \frac{V_3}{4} + \frac{V_4}{2}$$

KVL:

$$V_1 + V_4 = 8 + V_a$$

$$V_4 = 8 - V_1$$

$$I_2 = \frac{8}{4} + \frac{8 - V_1}{2}$$

$$I_2 = 2 + 4 - \frac{V_1}{2} = 6 - \frac{V_1}{2}$$

$I_1 = I_2$

$\frac{V_1}{2} = 6 - \frac{V_1}{2}$

$V_1 = 12 - V_1$

$2V_1 = 12$

$V_1 = 6V$

**2.87** If $V_1 = 5$ V in the circuit in Fig. P2.87, find $I_S$.

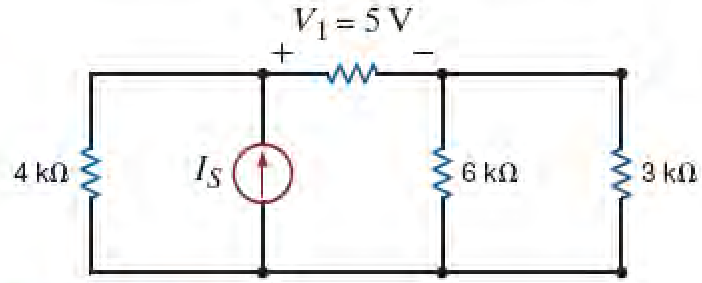
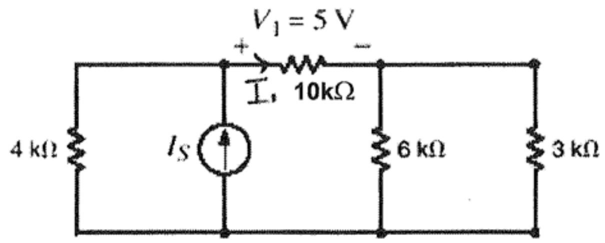
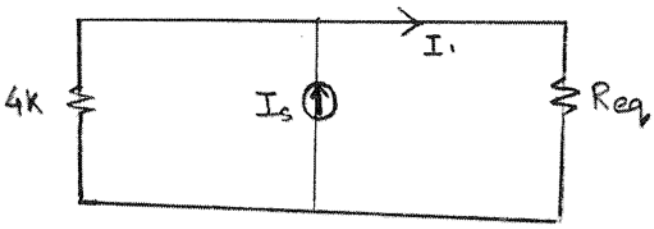



**Figure P2.87**

## SOLUTION:




$$I_1 = \frac{V_1}{10k} = \frac{5}{10k} = \frac{1}{2}\text{ mA}$$




$$R_{eq} = (6K \| 3K) + 10K$$

$$R_{eq} = 12K\Omega$$

$$I_1 = \left(\frac{4k}{4K+12k}\right) I_s$$

$$I_s = \frac{I_1}{\left(\frac{4k}{4k+12k}\right)} = \frac{\frac{1}{2}m}{\left(\frac{4k}{4k+12k}\right)}$$

$$I_s = 2mA$$

**2.88** In the network in Fig. P2.88, $V_1 = 12$ V. Find $V_S$.

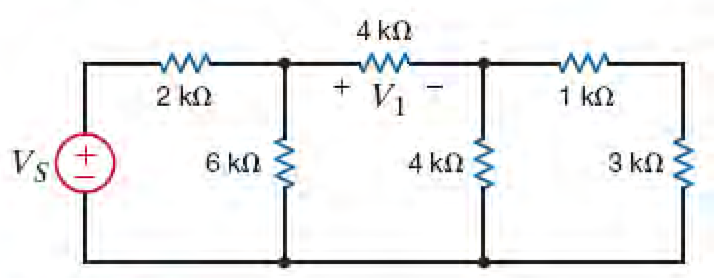
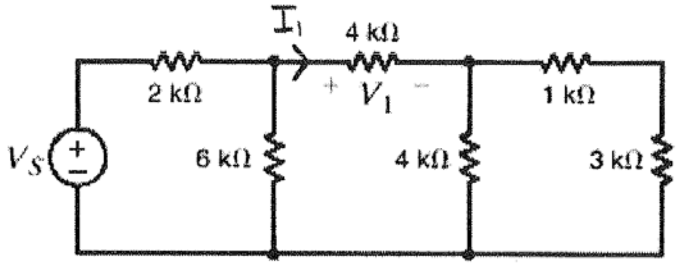
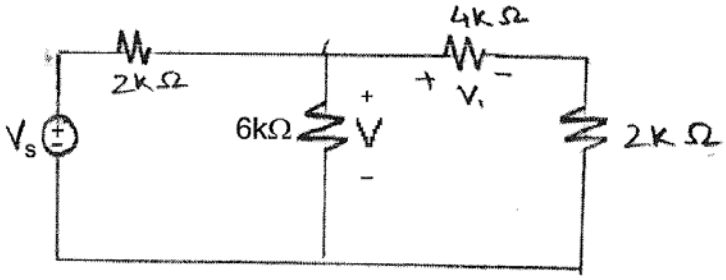



Figure P2.88

## SOLUTION:

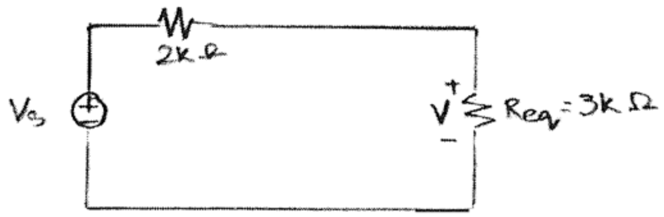



$$I_1 = \frac{V_1}{4k} = \frac{12}{4k} = 3\,mA$$




$$V_1 = \left(\frac{4K}{4K+2K}\right)V \quad \text{OR} \quad (3mA)(4K\Omega) = 18V$$

$$V = \frac{12}{\frac{4k}{4k+2k}} = 18\,V$$




$$R_{eq} = (4k + 2k) \parallel 6k$$

$$R_{eq} = 3k\ \Omega$$

$$V = \left(\frac{3k}{3k + 2k}\right) V_s$$

$$V_s = \frac{18}{\frac{3k}{3k + 2k}} = 30V$$

**2.89** Given that $V_o = 4$ V in the network in Fig. P2.89, find $V_S$.

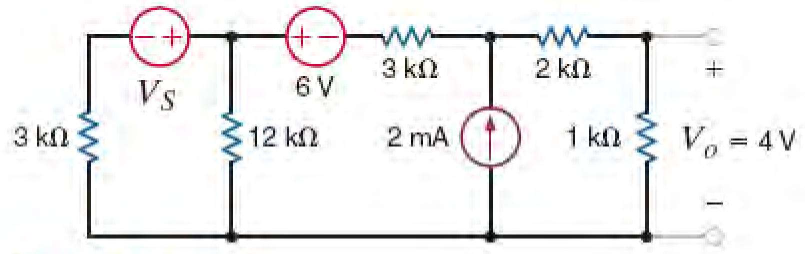
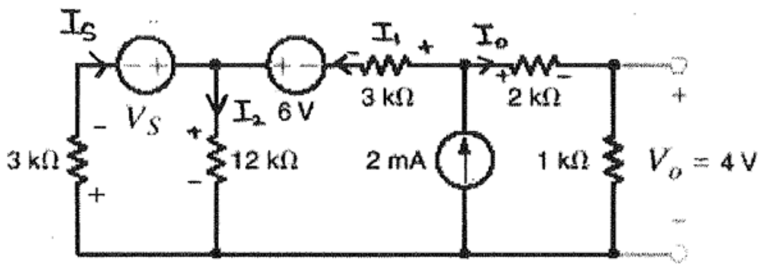



Figure P2.89

**SOLUTION:**




$$I_o = \frac{V_o}{1K} = \frac{4}{1k} = 4mA$$

$$I_1 + I_o = 2m$$

$$I_1 = 2m - 4m$$

$$I_1 = -2mA$$

KVL :

$$4 + I_o(2k) + 6 = I_1(3k) + I_2(12k)$$

$$(12k)I_2 = 4 + 4m(2k) + 6 - (-2m)(3k)$$

$$I_2 = 2mA$$

KCL:

$$I_s + I_1 = I_2$$

$$I_s = I_2 - I_1$$

$$I_s = 2m - (-2m)$$

$$I_s = 4mA$$

KVL:

$$V_s = 3K I_s + 12K I_2$$

$$V_s = 3K(4m) + 12K(2m)$$

$$V_s = 36V$$

**2.90** If $V_R = 15$ V, find $V_X$ in Fig. P2.90.

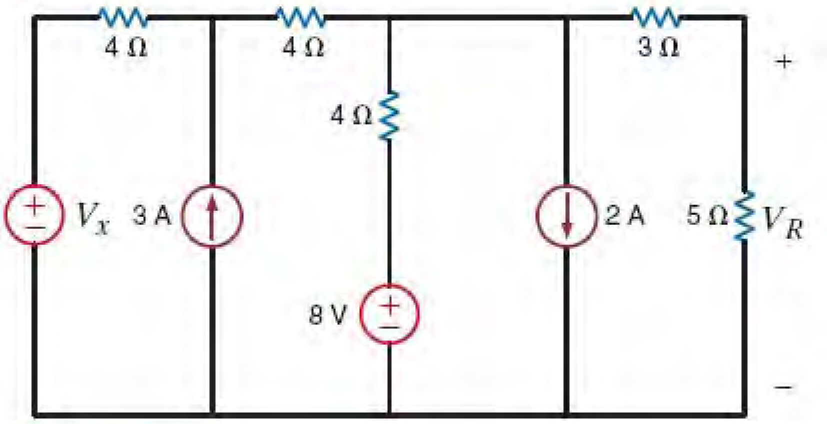
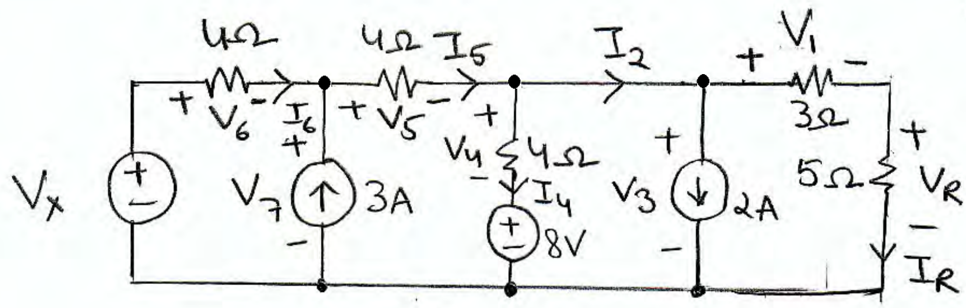



Figure P2.90

## SOLUTION:




$$I_R = \frac{V_R}{5} = \frac{15}{5} = 3A$$

$$V_1 = 3I_R = (3)(3) = 9V$$

$$I_2 = 2 + I_R = 5A \qquad V_3 = V_1 + V_R = 9 + 15 = 24V$$

$$V_4 = V_3 - 8 = 24 - 8 = 16V$$

$$I_4 = \frac{V_4}{4} = \frac{16}{4} = 4A$$

$$I_5 = I_2 + I_4 = 5 + 4 = 9A$$

$$V_5 = 4I_5 = 4(9) = 36V$$

$$I_6 = I_5 - 3 = 9 - 3 = 6A$$

$$V_7 = V_5 + V_4 + 8 = 36 + 16 + 8 = 60V$$

$$V_6 = 4I_6 = (4)(6) = 24V$$

$$V_x = V_6 + V_7 = 60 + 24 = \underline{84V}$$

**2.91** If $V_2 = 4$ V in Fig. P2.91, calculate $V_x$.

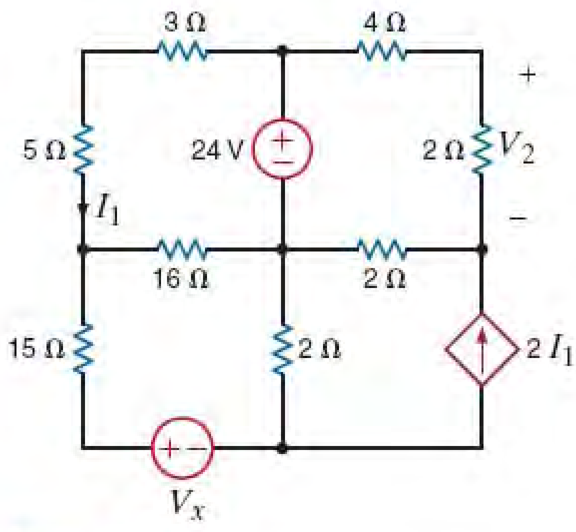
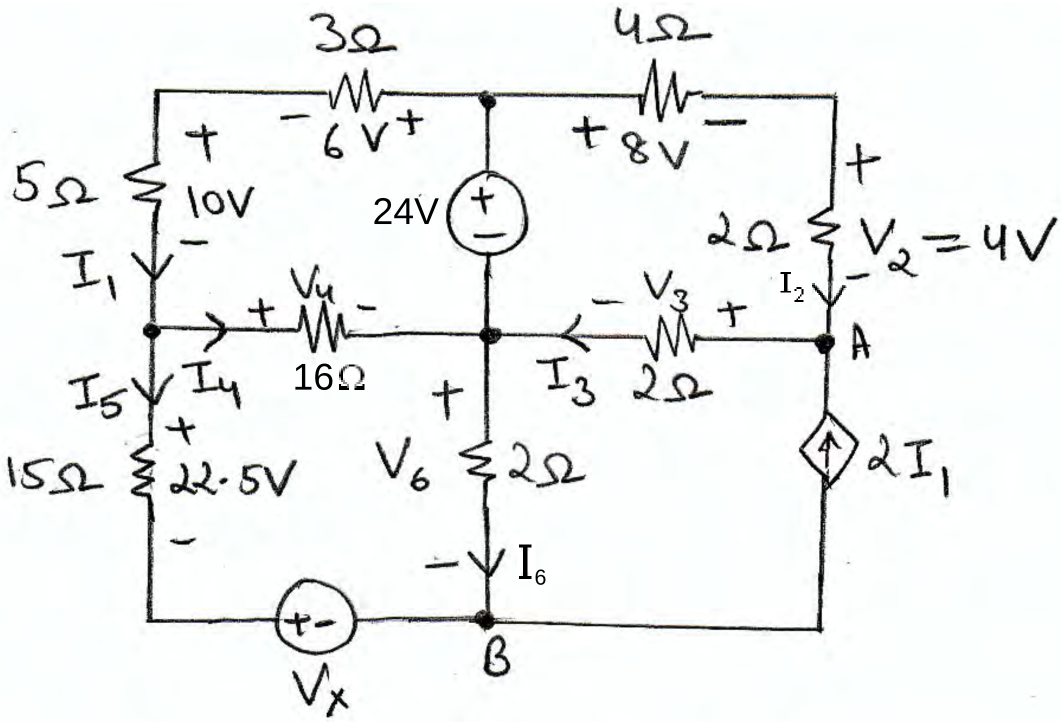



**Figure P2.91**

**SOLUTION:**




$$I_2 = \frac{4}{2} = 2A$$

$V_3 = -4 - 8 + 24 = 12V \quad I_3 = \frac{V_3}{2} = 6A$

KCL @ node A: $I_2 + 2I_1 = I_3$

$2 + 2I_1 = 6 \quad 2I_1 = 4 \quad I_1 = 2A$

$V_4 = -10 - 6 + 24 = 8V \quad I_4 = \frac{8}{16} = 0.5A$

$I_5 = I_1 - I_4 = 2 - 0.5 = 1.5A$

KCL @ node B: $I_6 + I_5 = 2I_1 = 4$

$I_6 = 4 - 1.5 = 2.5A \quad V_6 = 2I_6 = 5V$

$V_x = -22.5 + 8 + 5 = \underline{-9.5V}$

**2.92** Find the value of $I_A$ in the network in Fig. P2.92.

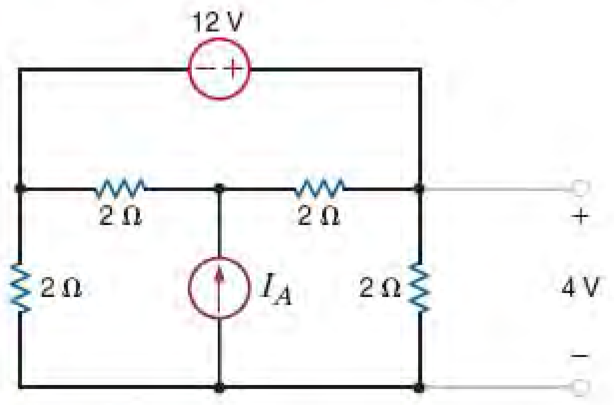
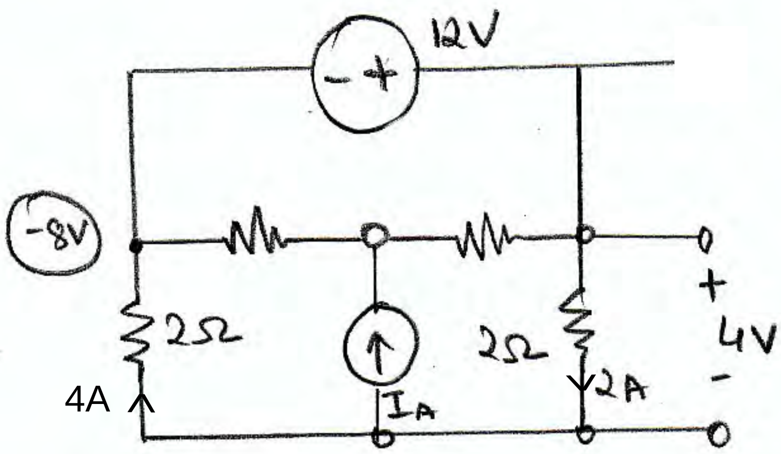



Figure P2.92

## SOLUTION:




$I_A = -2A$

**2.93** Find the value of $I_A$ in the circuit in Fig. P2.93.

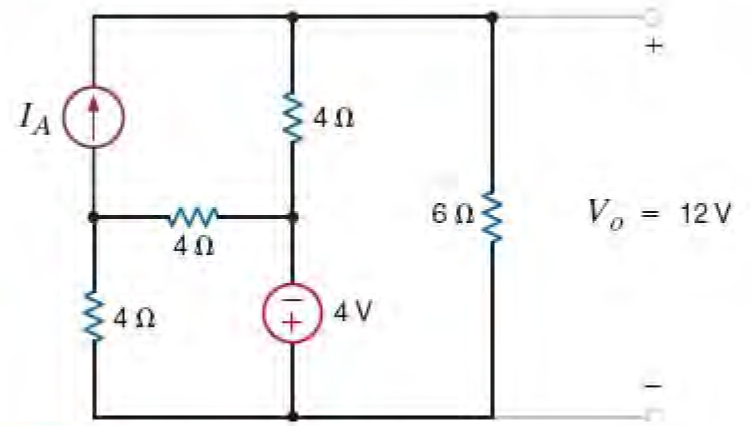
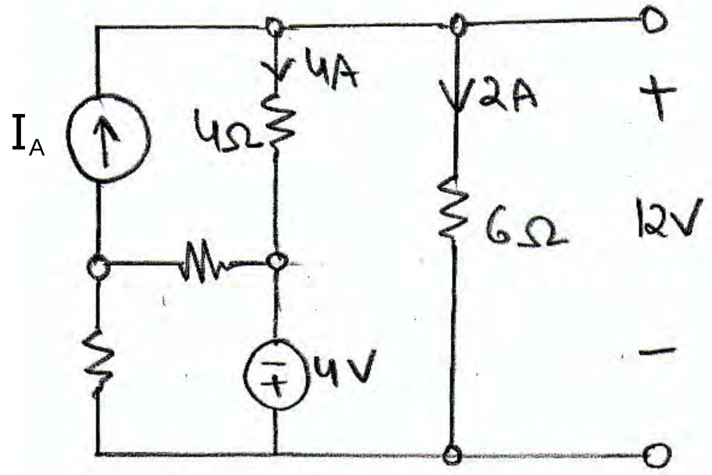



Figure P2.93

## SOLUTION:




$I_A = 6A$

**2.94** Find in value of the current source $I_A$ in the network in Fig. P2.94.

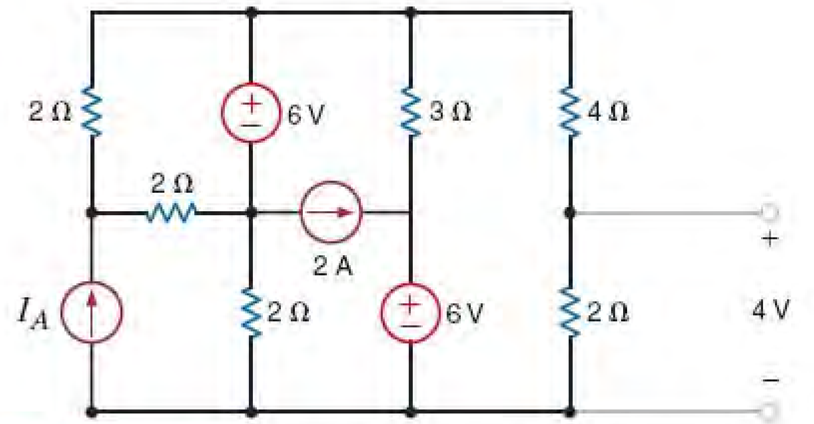
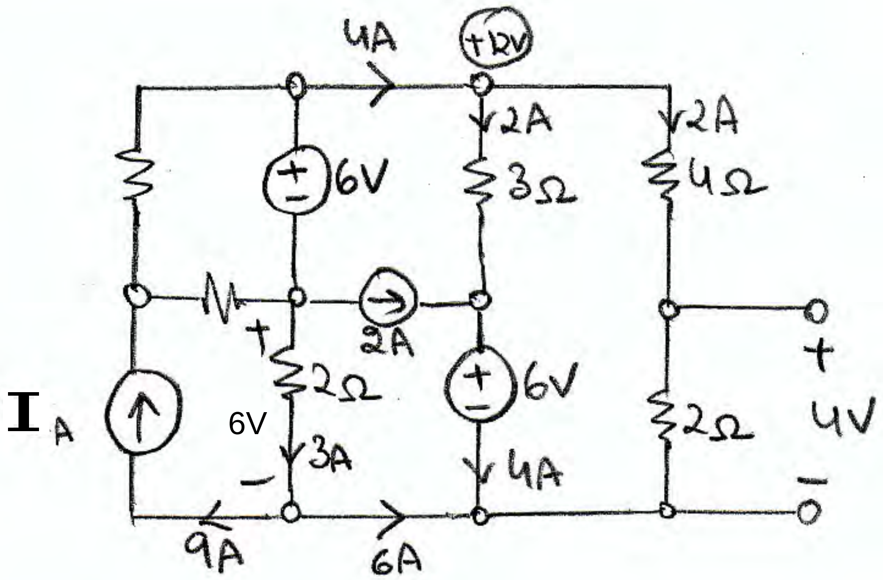



**Figure P2.94**

## SOLUTION:




$I_A = 9A$

**2.95** Given $V_o = 12$ V, find the value of $I_A$ in the circuit in Fig. P2.95.

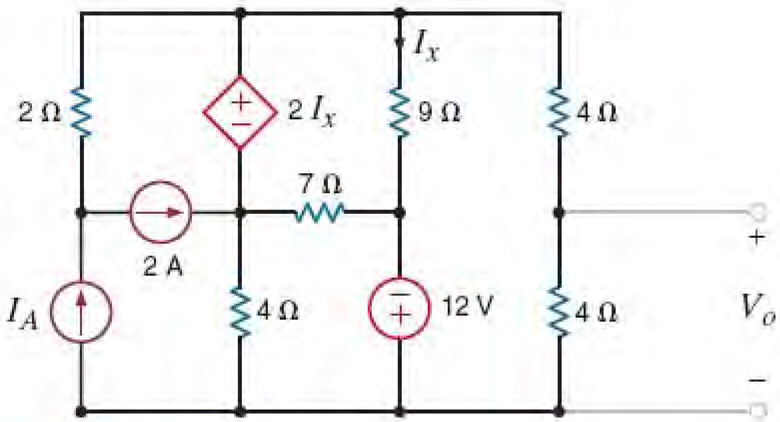
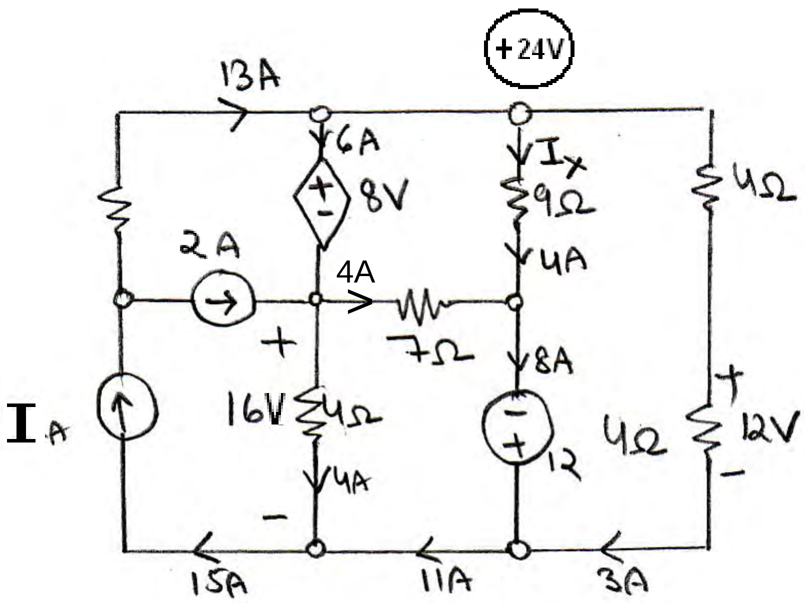



**Figure P2.95**

## SOLUTION:




$I_A = 15A$

**2.96** Find the value of $V_x$ in the network in Fig. P2.96, such that the 5-A current source supplies 50 W.

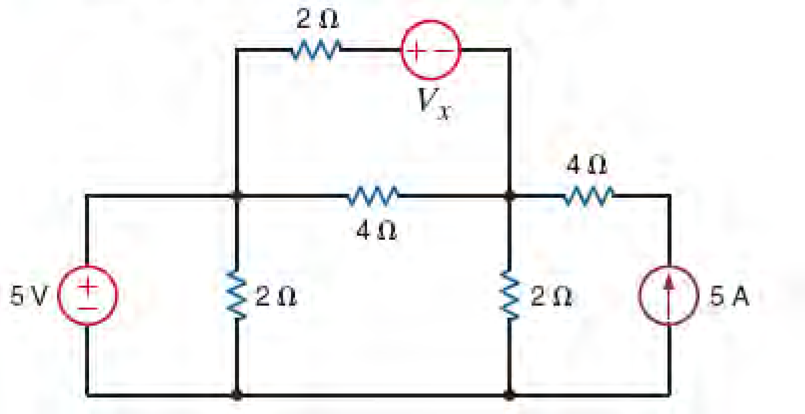
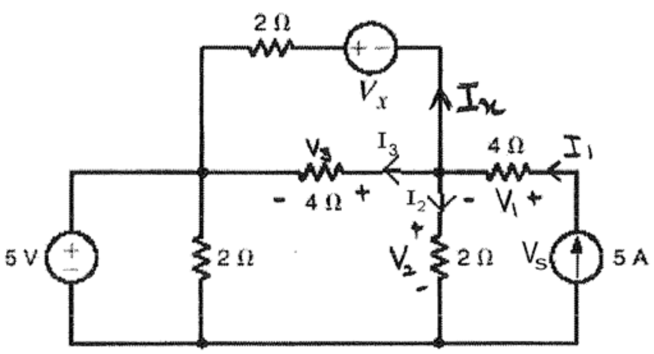



**Figure P2.96**

## SOLUTION:




$$P_{5A} = V_s I_1$$

$$V_s = \frac{50}{5} = 10V$$

$$V_1 = 5(4) = 20V$$

KVL:

$$V_s = V_1 + V_2$$

$$V_2 = 10 - 20$$

$$V_2 = -10V$$

$$I_2 = \frac{V_2}{2} = \frac{-10}{2}$$

$$I_2 = -5A$$

KVL:

$$5 + V_3 = V_2$$

$$V_3 = -10 - 5 = -15V$$

$$I_3 = \frac{V_3}{4} = \frac{-15}{4} A$$

KCL:

$$5 = I_2 + I_3 + I_x$$

$$I_x = 5 + 5 + \frac{15}{4}$$

$$I_x = 13.75A$$

KVL:

$$5 + 2I_x = V_2 + V_x$$

$$V_x = 5 + 2(13.75) + 10$$

$$V_x = 42.5V$$

**2.97** The 5-A current source in Fig. P2.97 supplies 150 W. Calculate $V_A$.

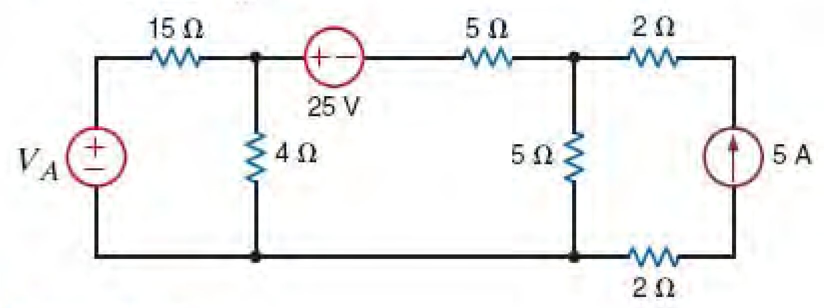
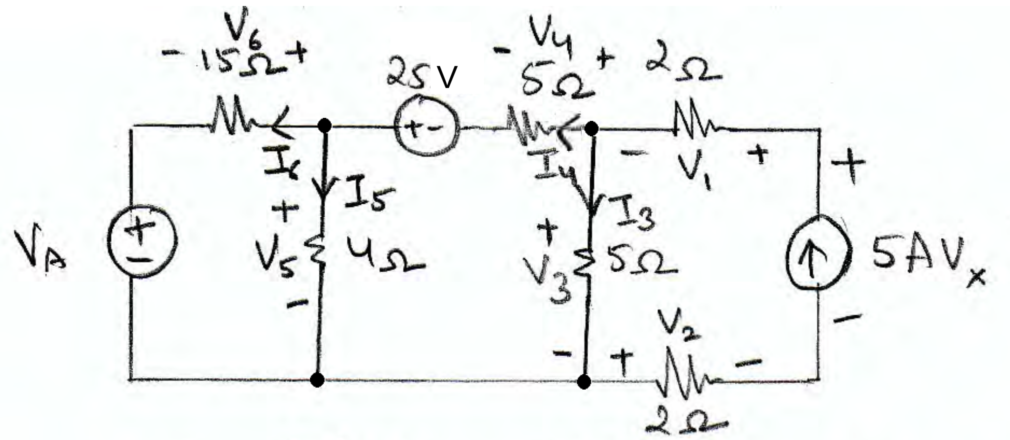



**Figure P2.97**

## SOLUTION:




$$V_1 = (5)(2) = 10V \qquad V_x = \frac{150}{5} = 30V$$

$$V_2 = (5)(2) = 10V$$

$$V_3 = -V_1 + V_x - V_2 = -10 + 30 - 10 = 10V$$

$$I_3 = \frac{V_3}{5} = \frac{10}{5} = 2A$$

$$I_4 = 5 - I_3 = 5 - 2 = 3A$$

$$V_4 = 5I_4 = (5)(3) = 15V$$

$$V_5 = 25 - V_4 + V_3 = 25 - 15 + 10 = 20V$$

$$I_5 = \frac{V_5}{4} = \frac{20}{4} = 5A$$

$$I_6 = I_4 - I_5 = 3-5 = -2A$$

$$V_6 = 15I_6 = 15(-2) = -30V$$

$$V_A = -V_6 + V_5 = -(-30) + 20 = \underline{50V}$$

**2.98** Given $I_o = 2$ mA in the circuit in Fig. P2.98, find $I_A$.

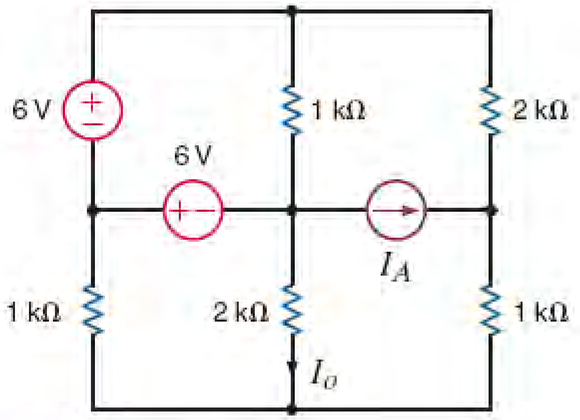
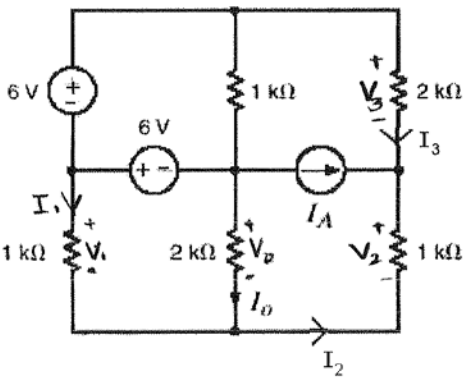



Figure P2.98

**SOLUTION:**




$$V_o = I_o(2k) = 2m(2k) = 4V$$

KVL:

$$V_1 = 6 + V_o$$

$$V_1 = 6 + 4 = 10V$$

$$I_1 = \frac{V_1}{1k} = \frac{10}{1k} = 10mA$$

KCL:

$$I_1 + I_o = I_2$$

$$I_2 = 10m + 2m = 12mA$$

$$V_2 = I_2(1K) = 12m(1K) = 12V$$

KVL:

$$V_3 = 6 + V_1 + V_2$$

$$V_3 = 6 + 10 + 12$$

$$V_3 = 28\text{ V}$$

$$I_3 = \frac{V_3}{2K} = \frac{28}{2K} = 14\text{mA}$$

KCL:

$$I_A + I_3 + I_2 = 0$$

$$I_A = -14m - 12m$$

$$I_A = -26\text{mA}$$

**2.99** Given $I_o = 2$ mA in the network in Fig. P2.99, find $V_A$.

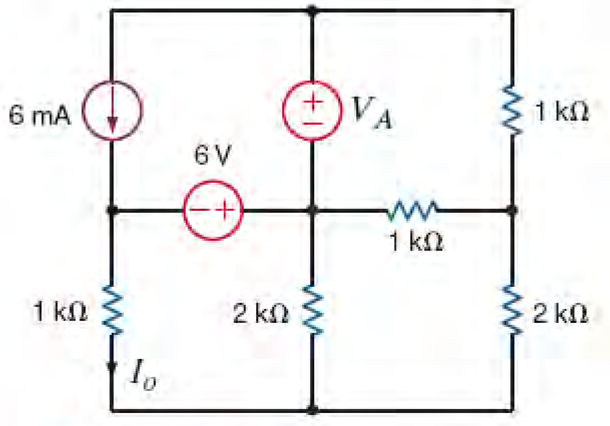
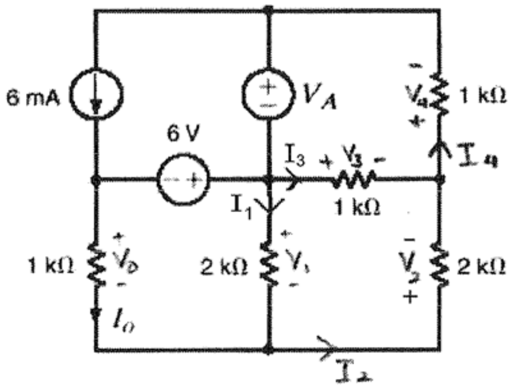



Figure P2.99

**SOLUTION:**




$V_o = I_o(1K) = 2m(1k) = 2V$

KVL:

$V_1 = V_o + 6$ $\qquad$ $I_1 = \frac{V_1}{2K}$

$V_1 = 2+6 = 8V$ $\qquad$ $I_1 = \frac{8}{2k} = 4mA$

KCL:

$I_o + I_1 = I_2$

$I_2 = 2m + 4m = 6mA$

$V_2 = I_2(2K) = 6m(2k) = 12V$

KVL:

$V_1 + V_2 = V_3$

$V_3 = 8 + 12 = 20V$

$I_3 = \frac{V_3}{1K} = \frac{20}{1K} = 20mA$

KCL:

$I_2 + I_3 = I_4$

$I_4 = 6m + 20m = 26mA$

$V_4 = I_4(1K) = 26m(1K) = 26V$

KVL:

$V_A + V_4 + V_3 = 0$

$V_A = -26 - 20$

$V_A = -46V$

**2.100** Given $V_o$ in the network in Fig. P2.100, find $I_A$.

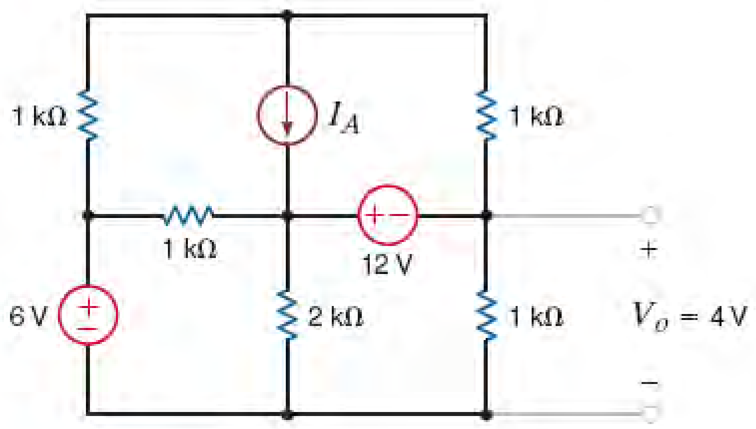
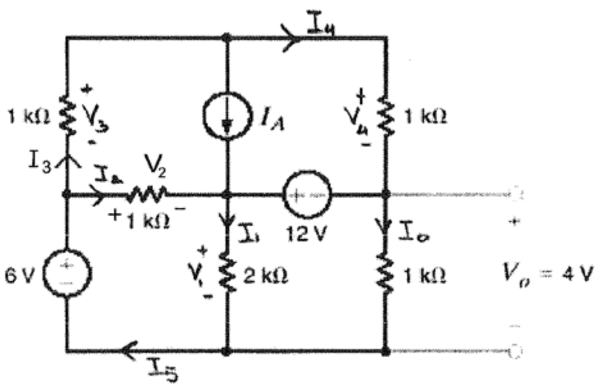



Figure P2.100

## SOLUTION:




$$I_o = \frac{V_o}{1K} = \frac{4}{1K} = 4mA$$

KVL:

$$V_1 = 12 + V_o = 12 + 4 = 16V$$

$$I_1 = \frac{V_1}{2K} = \frac{16}{2K} = 8mA$$

KVL:

$$6 = V_2 + V_1$$

$$V_2 = 6 - 16 = -10V$$

$$I_2 = \frac{V_2}{1K} = -\frac{10}{1K} = -10mA$$

KVL:

$V_2 + 12 = V_3 + V_4$

$\boxed{V_3 + V_4 = 2}$

KCL:

$I_1 + I_0 = I_5$

$I_5 = 8m + 4m = 12mA$

KCL:

$I_5 = I_3 + I_2$

$I_3 = 12m - (-10m) = 22mA$

$V_3 = I_3(1k) = 22m(1k) = 22V$

$V_3 + V_4 = 2$

$V_4 = 2 - 22$

$V_4 = -20V$

$I_4 = \frac{V_4}{1k} = \frac{-20}{1k}$

$I_4 = -20mA$

KCL:

$$I_o = I_A + I_4$$

$$I_A = 22m - (-20m)$$

$$I_A = 42mA$$

**2.101** Find the value of $V_x$ in the circuit in Fig. P2.101 such that the power supplied by the 5-A source is 60 W.

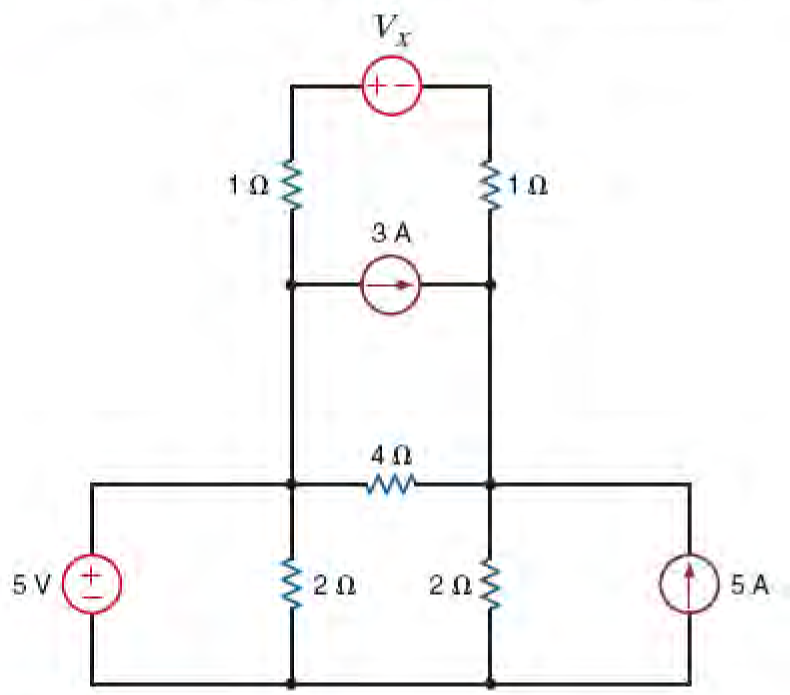
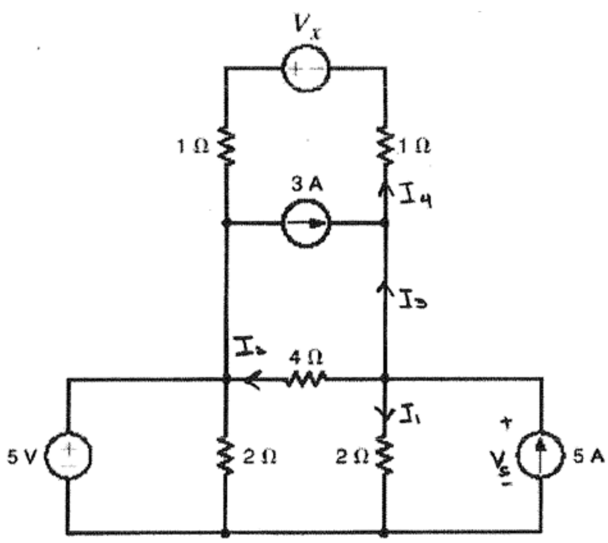



**Figure P2.101**

## SOLUTION:




$$P_{5A} = V_s(5)$$

$$V_s = \frac{60}{5} = 12V$$

$$I_1 = \frac{V_s}{2} = \frac{12}{2} = 6A$$

KVL:

$$V_s = V_2 + 5$$

$$V_2 = 12 - 5 = 7V$$

$$I_2 = \frac{V_2}{4} = \frac{7}{4} = 1.75A$$

KCL:

$$5 = I_1 + I_2 + I_3$$

$$I_3 = 5 - 6 - 1.75$$

$$I_3 = -2.75A$$

KCL:

$$3 + I_3 = I_4$$

$$I_4 = 3 - 2.75 = 0.25A$$

KVL:

$$V_2 + V_x = 1(I_4) + 1(I_4)$$

$$V_x = 1(0.25) + 1(0.25) - 7$$

$$V_x = -6.5V$$

**2.102** The 3-A current source in Fig. P2.102 is absorbing 12 W. Determine $R$.

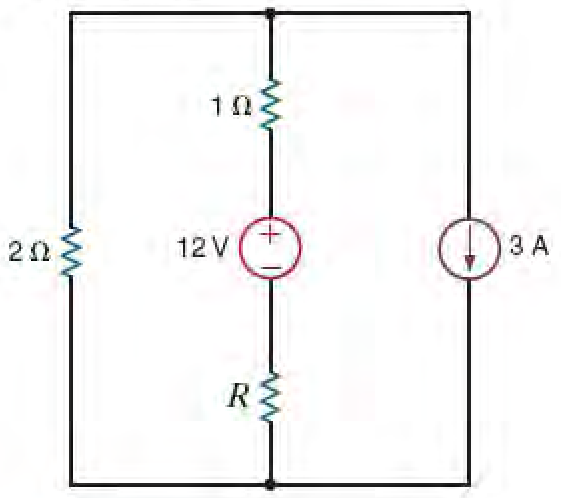
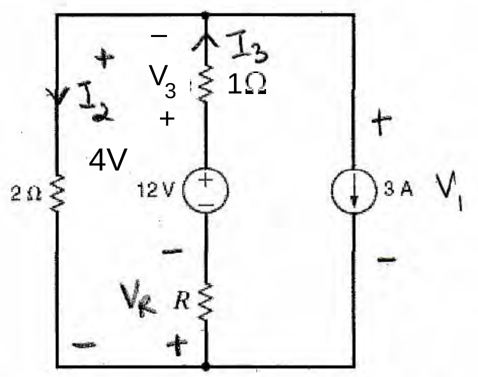



Figure P2.102

## SOLUTION:




$12 = 3V_1 \qquad V_1 = \frac{12}{3} = 4V$

$I_2 = \frac{V_1}{2} = \frac{4}{2} = 2A$

$I_3 = I_2 + 3 = 5A$

$$V_3 = 1I_3 = 5V$$

$$V_R = -V_1 - V_3 + 12 = -4 - 5 + 12$$

$$V_R = 3V$$

$$R = \frac{V_R}{I_3} = \frac{3}{5} = \underline{0.6\,\Omega}$$

**2.103** If the power supplied by the 50-V source in Fig. P2.103 is 100 W, find $R$.

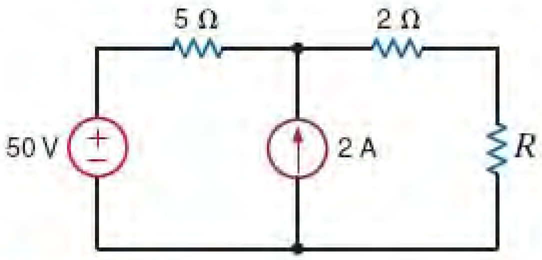
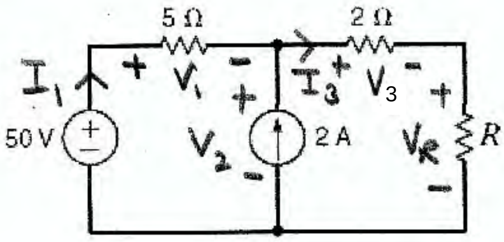



Figure P2.103

**SOLUTION:**




$$100 = 50 I_1$$

$$I_1 = 2A$$

$$V_1 = 5I_1 = (5)(2) = 10V$$

$$V_2 = -V_1 + 50 = -10 + 50 = 40V$$

$$I_3 = I_1 + 2 = 4A$$

$$V_3 = 2I_3 = 2(4) = 8V$$

$$V_R = -V_3 + V_2 = -8 + 40 = 32V$$

$$R = \frac{V_R}{I_3} = \frac{32}{4} = 8\Omega$$

**2.104** Given that $V_1 = 4$ V, find $V_A$ and $R_B$ in the circuit in Fig. P2.104.

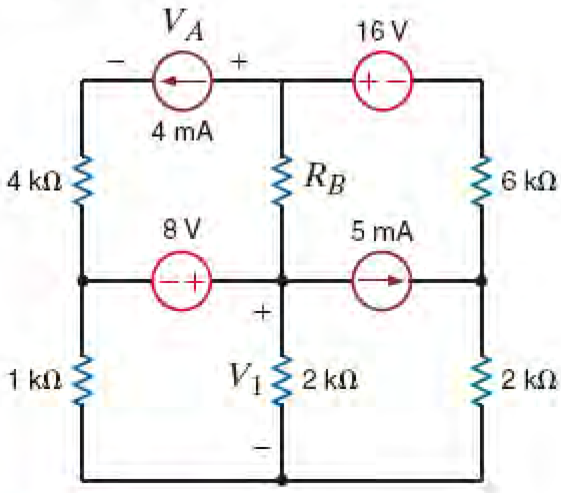
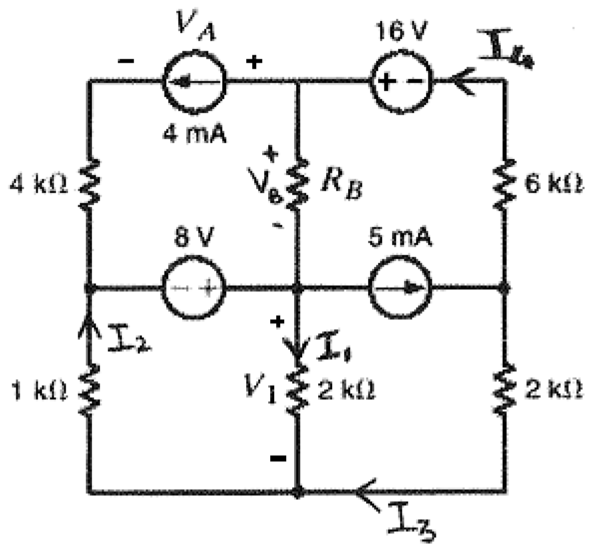



Figure P2.104

**SOLUTION:**




$$V_1 = I_1(2K)$$

$$I_1 = \frac{4}{2K} = 2mA$$

KVL:

$$V_1 + 1K I_2 = 8$$

$$I_2 = \frac{8-4}{1K} = 4mA$$

KCL :

$$I_1 + I_3 = I_2$$

$$I_3 = 4m - 2m$$

$$I_3 = 2mA$$

KCL :

$$I_3 + I_4 = 5mA$$

$$I_4 = 3mA$$

KCL :

$$I_4 = I_B + 4m$$

$$I_B = -1mA$$

KVL :

$$2kI_3 + 16 = 6K\,I_4 + V_B + V_1$$

$$V_B = 2k(2m) + 16 - 6k(3m) - 4$$

$$V_B = -2V$$

$$V_B = I_B R_B$$

$$R_B = \frac{-2}{-1m} = 2K\Omega$$

KVL:

$$8 + V_B = V_A + 4k(4m)$$

$$V_A = 8 - 2 - 4k(4m)$$

$$V_A = -10\text{ V}$$

**2.105** Find the power absorbed by the network in Fig. P2.105.

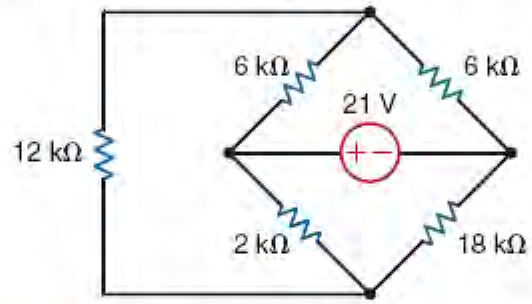
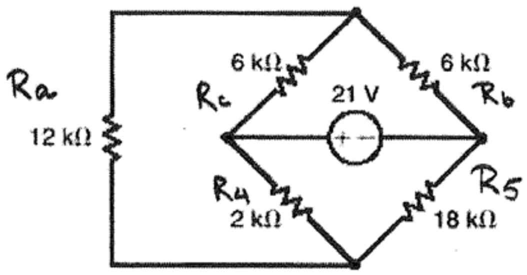



Figure P2.105

## SOLUTION:




Ra, Rb, and Rc are connected in wye.

$$R_1 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_b}$$

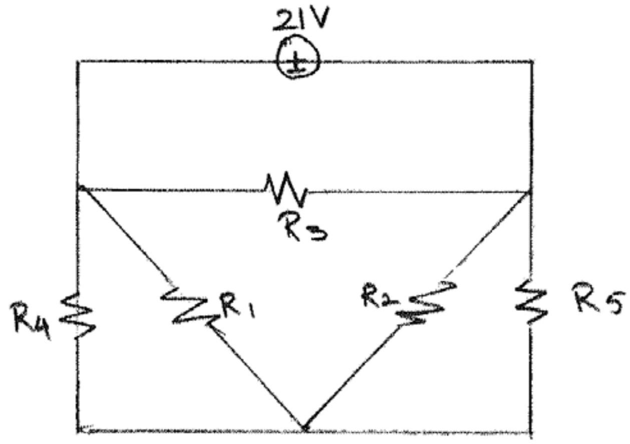
$R_a = 12K\Omega$, $R_b = 6K\Omega$, $R_c = 6K\Omega$, $R_4 = 2K\Omega$, and $R_5 = 18K\Omega$

$$R_1 = \frac{12K(6K) + 6K(6K) + 12K(6K)}{6K} = 30K\Omega$$

$$R_2 = 30K\Omega$$

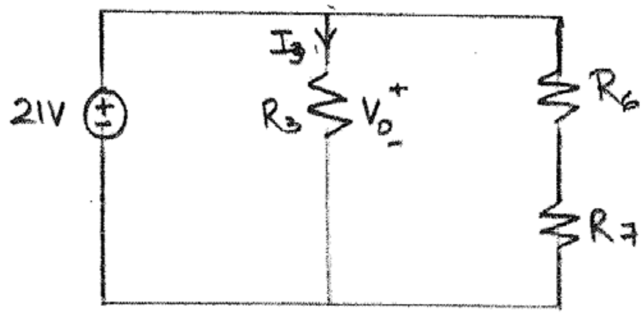
$$R_3 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_a} = \frac{12k(6k) + 6k(6k) + 12k(6k)}{12K}$$

$$R_3 = 15K\Omega$$




$$R_6 = R_4 \| R_1 = \frac{2k(30k)}{2k + 30k} = 1.875\,K\,\Omega$$

$$R_7 = R_2 \| R_5 = \frac{30k(18k)}{30k + 18k} = 11.25\,K\,\Omega$$




$$P = \frac{V_o^2}{R_3} + \frac{V_o^2}{R_6 + R_7}$$

$$P = \frac{(21)^2}{15K} + \frac{(21)^2}{1.875K + 11.25K}$$

$$P = 63\,mW$$

**2.106** Find the value of $g$ in the network in Fig. P2.106 such that the power supplied by the 3-A source is 20 W.

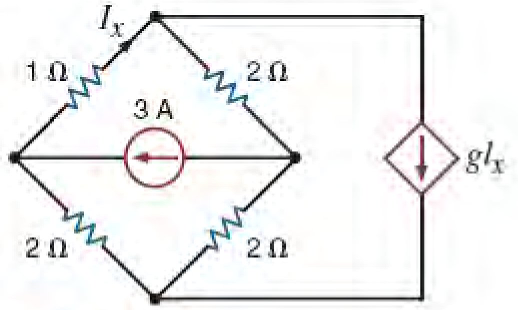
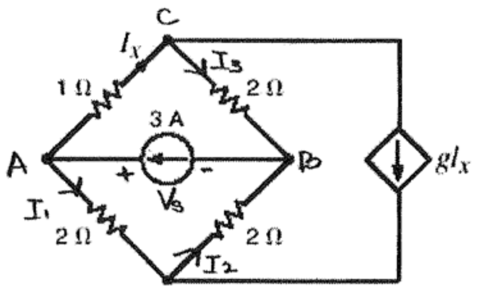



Figure P2.106

## SOLUTION:




$$P = V_s I_s$$

$$20 = V_s(3)$$

$$V_s = \frac{20}{3}\ V$$

KVL:

$$V_s = I_x + 2I_3 \quad — \ (1)$$

KCL at A:

$$3 = I_1 + I_x$$

Putting eqn (1) for $I_x$

$$I_x = 3 - I_1$$

$$V_3 = \underbrace{3 - I_1}_{I_2} + 2I_3$$

$$\frac{20}{3} - 3 = -I_1 + 2I_3$$

$$\boxed{11 = -3I_1 + 6I_3}$$

KVL:

$$V_3 = 2I_1 + 2I_2$$

KCL at B:

$$3 = I_2 + I_3$$

$$I_2 = 3 - I_3$$

$$\frac{20}{3} = 2I_1 + 2(3 - I_3)$$

$$\boxed{2 = 6I_1 - 6I_3}$$

$$-3I_1 + 6I_3 = 11$$

$$6I - 6I_3 = 2$$

$$I_1 = 4.33A$$

$$I_3 = 4A$$

$I_x = 3 - I_1$

$I_x = 3 - 4.33$

$I_x = -1.33A$

KCL at C :

$I_x = I_3 + gI_x$

$-1.33 = 4 + g(-1.33)$

$g = 4$

**2.107** Find the power supplied by the 24-V source in the circuit in Fig. P2.107.

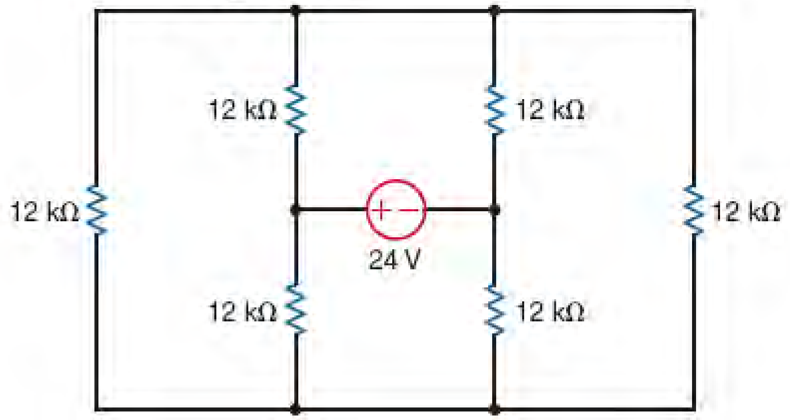
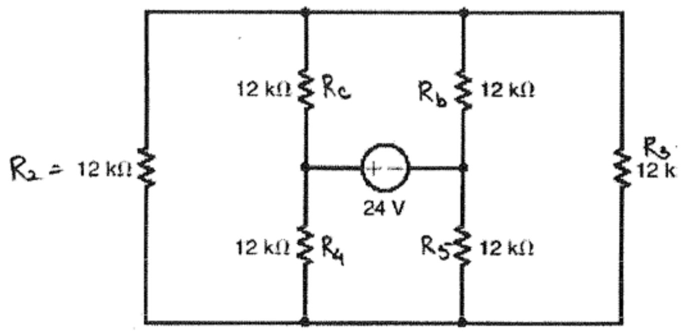


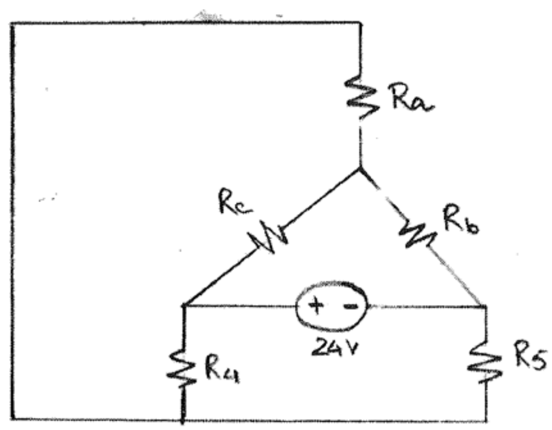

Figure P2.107

## SOLUTION:




$R_a = R_2 \| R_3 = 6K\Omega$

$R_a = 6K\Omega$



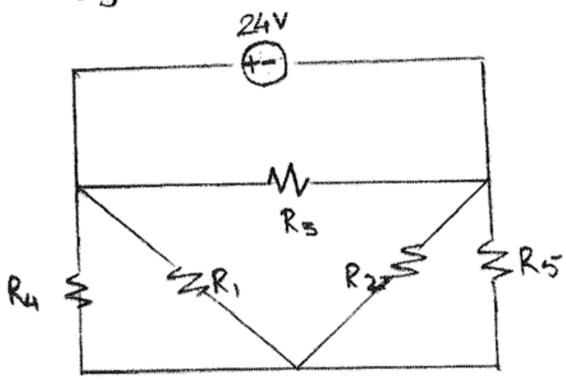

Ra, Rb, and Rc are wye connected:

$$R_1 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_b}$$

$$R_1 = \frac{6K(12K) + 12K(12K) + 6K(12K)}{12K} = 24K\Omega$$

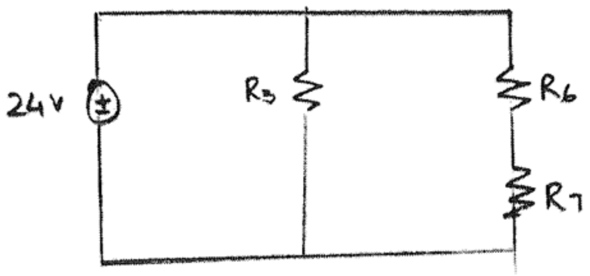
$$R_2 = 24K\Omega$$

$$R_3 = 48K\Omega$$




$$R_6 = R_1 \| R_4 = 24K \| 12K = 8K\Omega$$

$$R_7 = R_2 \| R_5 = 24K \| 12K = 8K\Omega$$




$$P = \frac{(24)^2}{48K} + \frac{(24)^2}{8k + 8K}$$

$$P = 48\,mW$$

**2.108** Find $I_o$ in the circuit in Fig. P2.108.

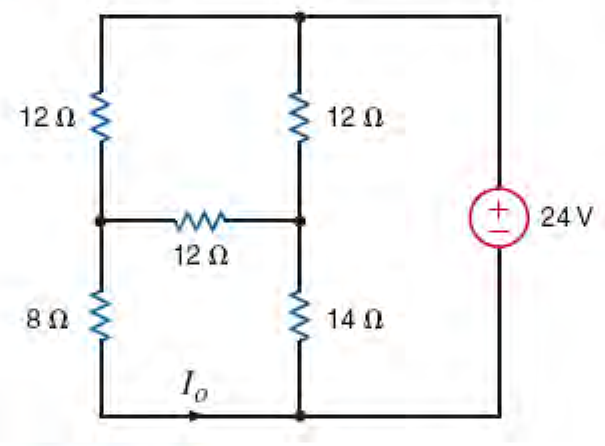
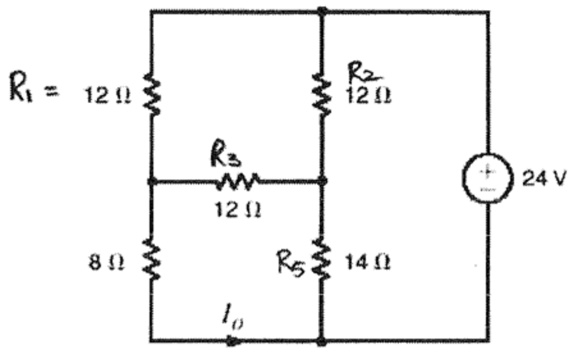
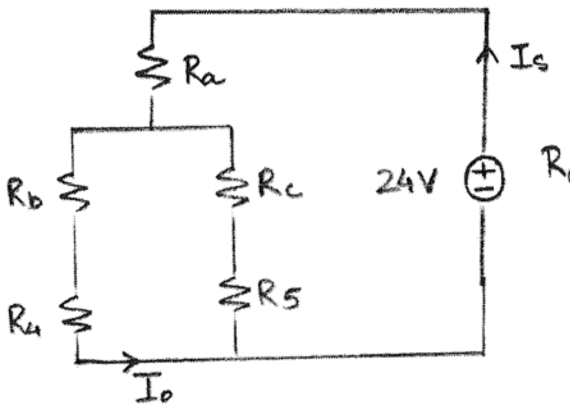



**Figure P2.108**

## SOLUTION:




$R_1$, $R_2$ and $R_3$ are connected in delta.




$R_a = R_b = R_c = 4\ \Omega$

$$R_{eq} = \left[(R_b + R_4) \parallel (R_c + R_5)\right] + R_a$$

$$R_{eq} = (12 \parallel 18) + 4 = \frac{12(18)}{12+18} + 4 = 11.2\ \Omega$$

$$I_s = \frac{24}{R_{eq}} = \frac{24}{11.2} = 2.14\text{A}$$

$$I_o = \left(\frac{R_C + R5}{R_C + R_5 + R_D + R_4}\right) I_s = \left(\frac{4+14}{4+14+4+8}\right)(2.14)$$

$$I_o = 1.29\text{A}$$

**2.109** Find $I_o$ in the circuit in Fig. P2.109.

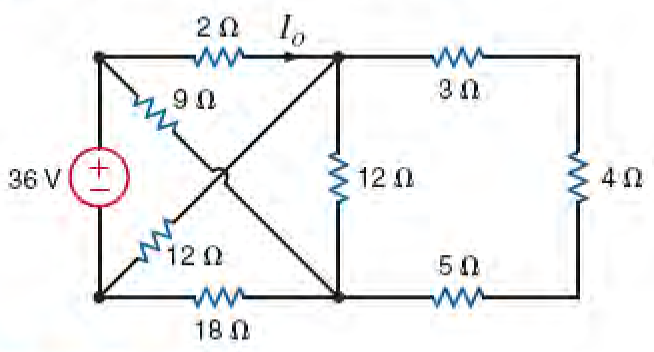
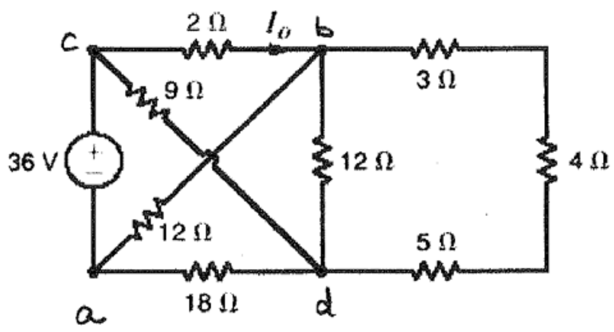
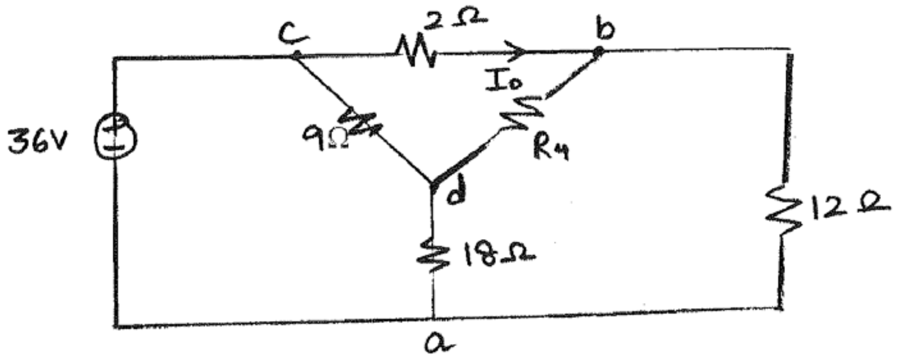



Figure P2.109

**SOLUTION:**

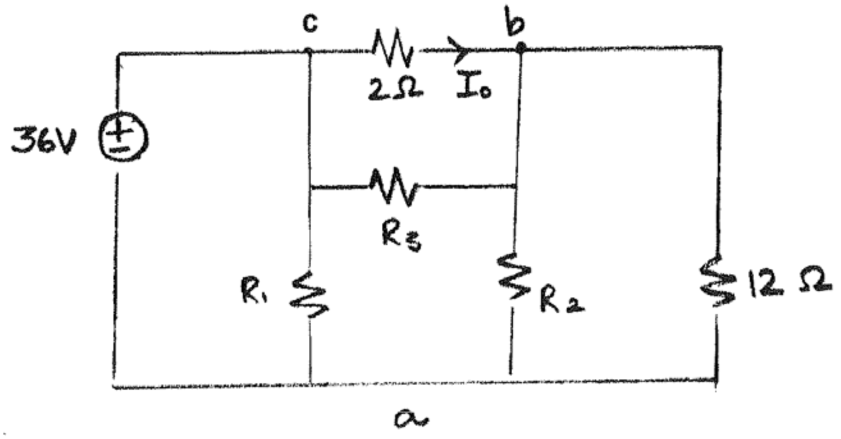



$R_4 = 12 \| (3+4+5) = 6\,\Omega$

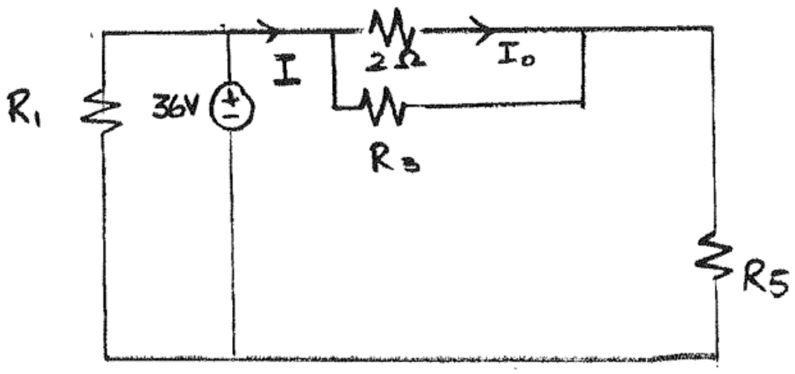



18 Ω, 9 Ω, and $R_4$ are wye connected.

$R_1 = 54\,\Omega$, $R_2 = 36\,\Omega$, and $R_3 = 18\,\Omega$




$$R_5 = R_2 \| 12 = 36 \| 12 = 9\,\Omega$$




$$R_{eq} = (2 \| R_3) + R_5 = (2 \| 18) + 9\,\Omega$$

$$R_{eq} = 10.8\,\Omega$$

$$I = \frac{36}{10.8} = 3.33\,A$$

$$I_o = \left(\frac{R_3}{R_3+2}\right)(I) = \left(\frac{18}{18+2}\right)(3.33)$$

$$I_o = 3A$$

**2.110** Determine the value of $V_o$ in the network in Fig. P2.110.

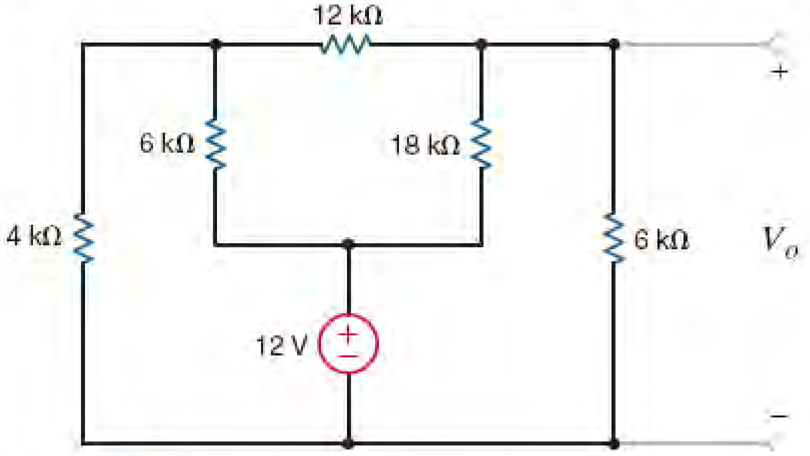
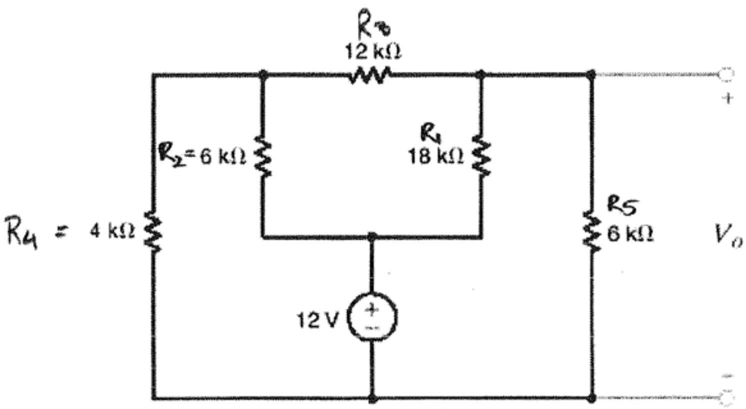



**Figure P2.110**

## SOLUTION:

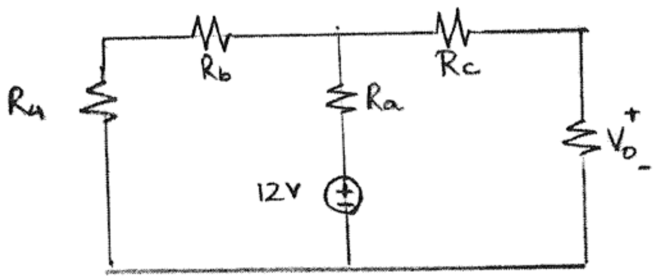



Using a delta to wye transformation:

$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3} = \frac{18K(6K)}{18K + 6K + 12K} = 3K\,\Omega$$

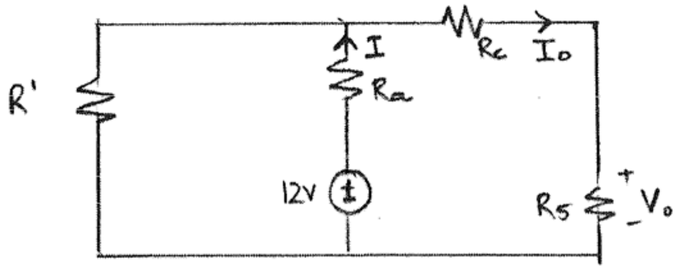
$$R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3} = \frac{6K(12K)}{18K + 6K + 12K} = 2K\,\Omega$$

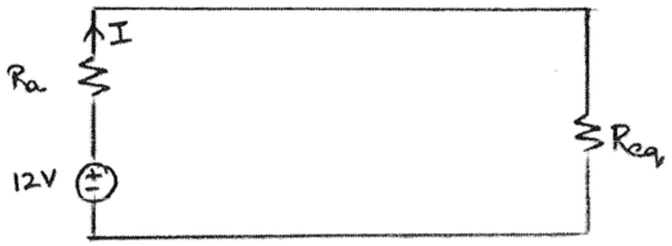
$$R_c = \frac{R_1 R_3}{R_1 + R_2 + R_3} = \frac{18K(12K)}{18K + 6K + 12K} = 6K\,\Omega$$



$$R' = R_4 + R_b = 4K + 2K$$

$$R' = 6K\ \Omega$$




$$R_{eq} = R' \parallel (R_c + R_5) = 6K \parallel (6K + 6K)$$

$$R_{eq} = 6K \parallel 12K = \frac{6K(12K)}{6K + 12K} = 4K\ \Omega$$

$$I = \frac{12}{R_a + R_{eq}} = \frac{12}{3K + 4K}$$

$$I = 1.714\ mA$$

Using current division:

$$I_o = \left(\frac{R'}{R' + R_c + R_5}\right)(I)$$

$$I_o = \left(\frac{6k}{6k+6k+6k}\right)(1.714m)$$

$$I_o = 0.571\,mA$$

$$V_o = I_o R_5 = (0.571m)(6k)$$

$$V_o = 3.43V$$

**2.111** Find $V_o$ in the circuit in Fig. P2.111.

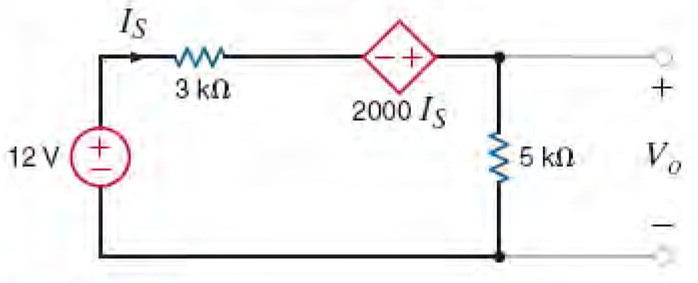



**Figure P2.111**

## SOLUTION:

KVL:

$$12 + 2000 I_s = 3K I_s + 5K I_s$$

$$6K I_s = 12$$

$$I_s = 2mA$$

$$V_o = I_s (5K)$$

$$V_o = 2m(5K)$$

$$V_o = 10V$$

**2.112** Find $V_o$ in the network in Fig. P2.112.

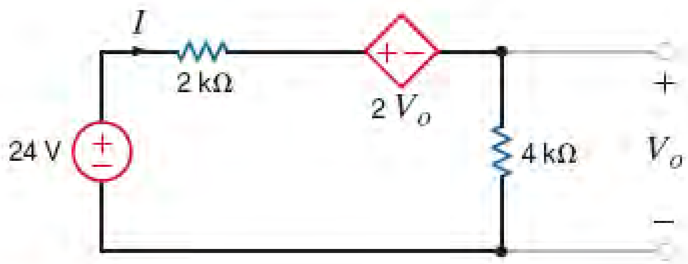



Figure P2.112

## SOLUTION:

KVL:

$$24 = 2K I + 2V_o + V_o$$

$$I = \frac{24 - 3V_o}{2K}$$

$$V_o = I(4k) = \left(\frac{24-3V_o}{2K}\right)(4K)$$

$$V_o = 48 - 6V_o$$

$$7V_o = 48 - 6V_o$$

$$7V_o = 48$$

$$V_o = 6.86V$$

**2.113** Find $I_o$ in the circuit in Fig. P2.113.

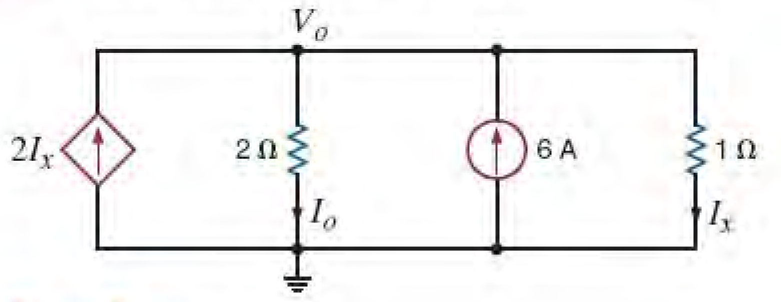



Figure P2.113

## SOLUTION:

$$-2I_x + \frac{V_o}{2} - 6 + \frac{V_o}{1} = 0$$

$$I_x = \frac{V_o}{1}$$

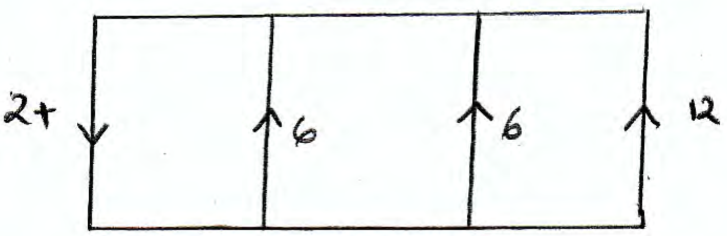
$$-2V_o + \frac{V_o}{2} + \frac{V_o}{1} = 6$$

$$-2V_o + 3/2\,V_o = 6$$

$$-1/2\,V_o = 6$$

$$V_o = -12V$$

$$I_o = \frac{V_o}{2} = -6A$$



**2.114** Find $I_o$ in the circuit in Fig. P2.114.

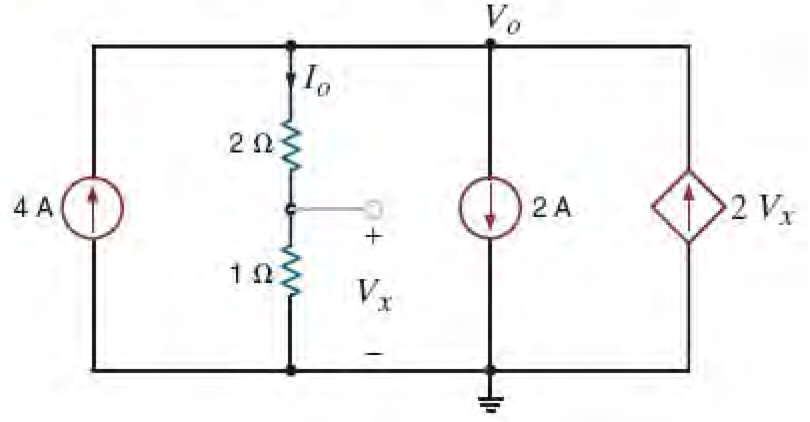



Figure P2.114

**SOLUTION:**

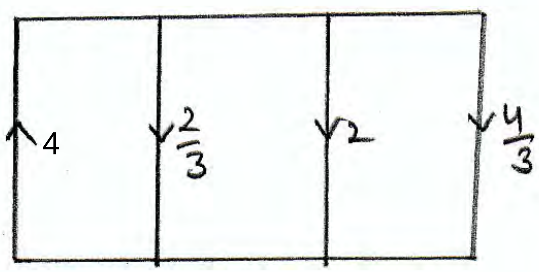
$$-4 + \frac{V_o}{3} + 2 + 2V_x = 0$$

$$V_x = \frac{1}{3} V_o$$

$$-4 + \frac{V_o}{3} + 2 + \frac{2}{3} V_o = 0$$

$$V_o = 2$$

$$I_o = \frac{V_o}{3} = \frac{2}{3}\,A$$



**2.115** Find $V_o$ in the circuit in Fig. P2.115.

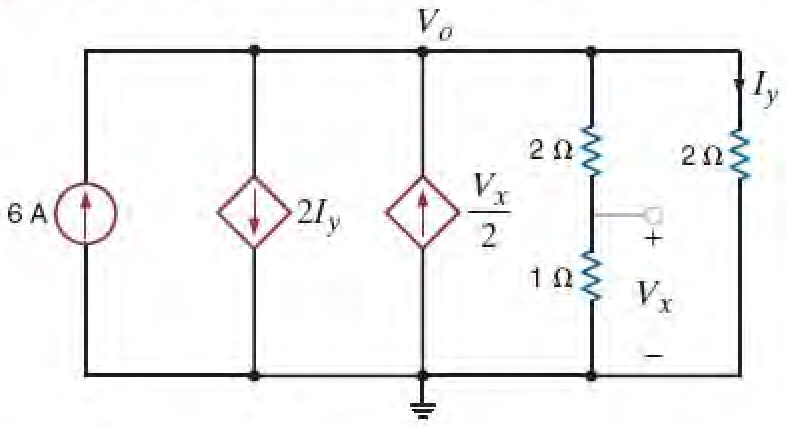



Figure P2.115

**SOLUTION:**

$$-6 + 2I_y - \frac{V_x}{2} + \frac{V_o}{3} + \frac{V_o}{2} = 0$$

$$V_x = \frac{1}{3} V_o, \quad I_y = \frac{V_o}{2}$$

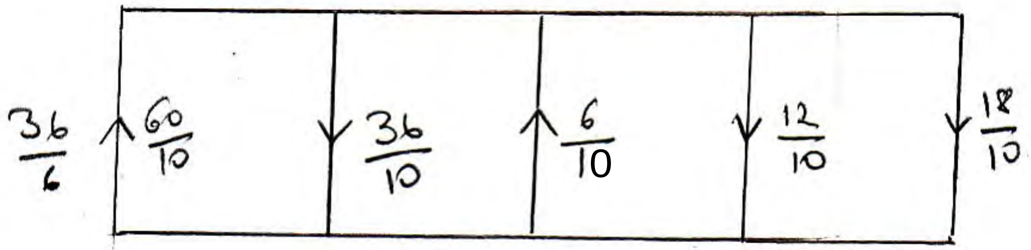
$$-6 + 2\left(\frac{V_o}{2}\right) - \frac{1}{2}\left(\frac{V_o}{3}\right) + \frac{V_o}{3} + \frac{V_o}{2} = 0$$

$$-6 + V_o - \frac{V_o}{6} + \frac{V_o}{3} + \frac{V_o}{2} = 0$$

$$V_o\left(\frac{6}{6} - \frac{1}{6} + \frac{2}{6} + \frac{3}{6}\right) = 6$$

$$V_o\left(\frac{10}{6}\right) = 6$$

$$V_o = \frac{36}{10} = 3.6$$


36/6
60/10
36/10
6/10
12/10
18/10

**2.116** Find $V_x$ in the network in Fig. P2.116.

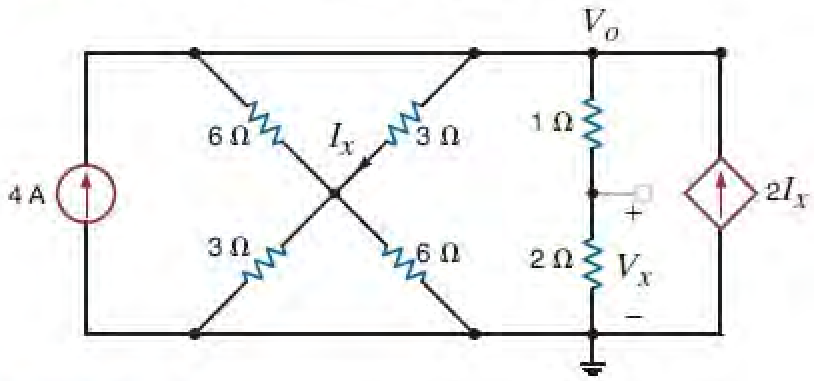
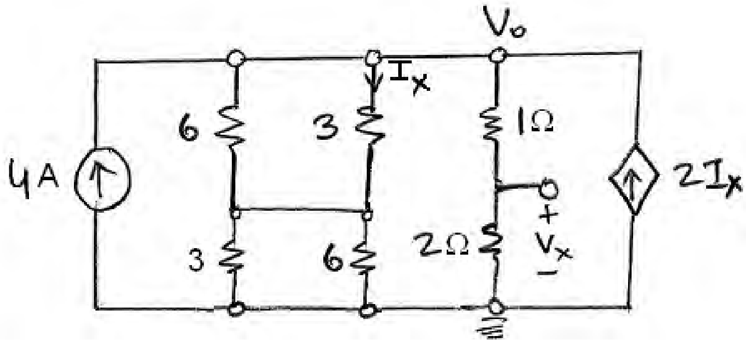
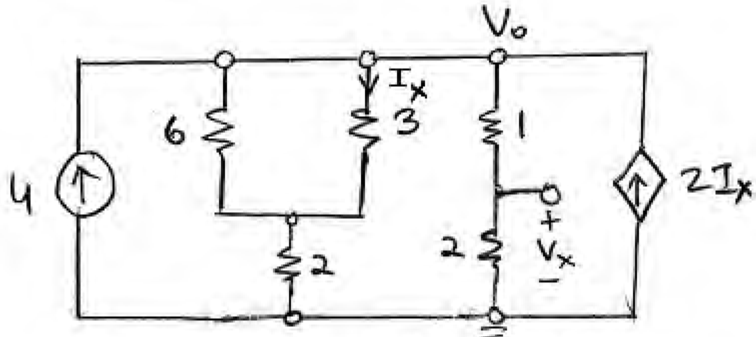



**Figure P2.116**

**SOLUTION:**




$$I_x = \left(\frac{1}{2}V_o\right)\left(\frac{1}{3}\right) = \frac{V_o}{6}$$

$$-4 + \frac{V_o}{4} + \frac{V_o}{3} - 2I_x = 0$$

$$-4 + \frac{V_o}{4} + \frac{V_o}{3} - \frac{V_o}{3} = 0$$

$$V_o = 16V$$

$$V_x = 2/3\,(16) = \frac{32}{3}\,V$$

**2.117** Find $V_o$ in the network in Fig. P2.117.

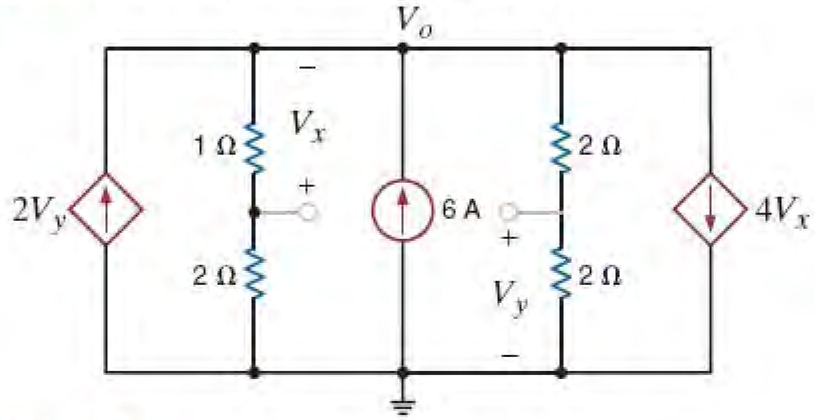



Figure P2.117

**SOLUTION:**

$$-2V_y + \frac{V_o}{3} - 6 + \frac{V_o}{4} + 4V_x = 0$$

$$V_x = \frac{-V_o}{3} \qquad V_y = \frac{V_o}{2}$$

$$-V_o + \frac{V_o}{3} - 6 + \frac{V_o}{4} - \frac{4}{3}V_o = 0$$

$$\left(-1 + \frac{1}{3} + \frac{1}{4} - \frac{4}{3}\right)V_o = 6$$

$$\left(\frac{-12+4+3-16}{12}\right)V_o = 6$$

$$V_o = \frac{-72}{21}\,V = -\frac{72}{21}\,V$$

**2.118** Find $I_1$, $I_2$, and $I_3$ in the circuit in Fig. P2.118.

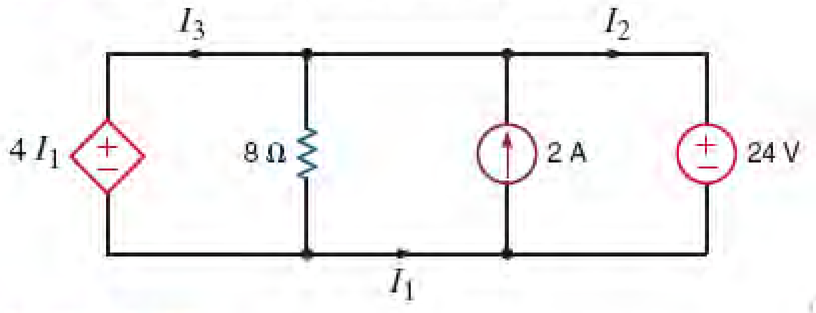
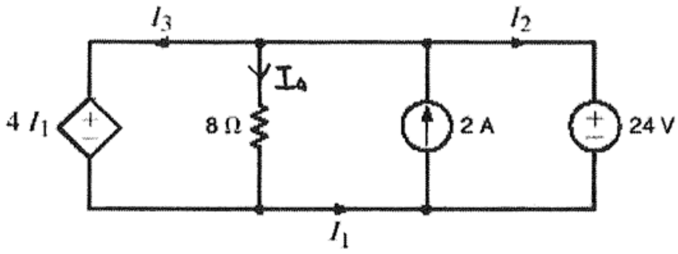



Figure P2.118

## SOLUTION:




$$I_4 = \frac{24}{8} = 3A$$

$$4I_1 = 24$$

$$I_1 = 6A$$

KCL:

$$I_1 + I_2 = 2$$

$$I_2 = 2 - 6$$

$$I_2 = -4A$$

KCL:

$$I_1 = I_3 + I_4$$

$$I_3 = 6 - 3$$

$$I_3 = 3A$$

**2.119** Find $I_o$ in the network in Fig. P2.119.

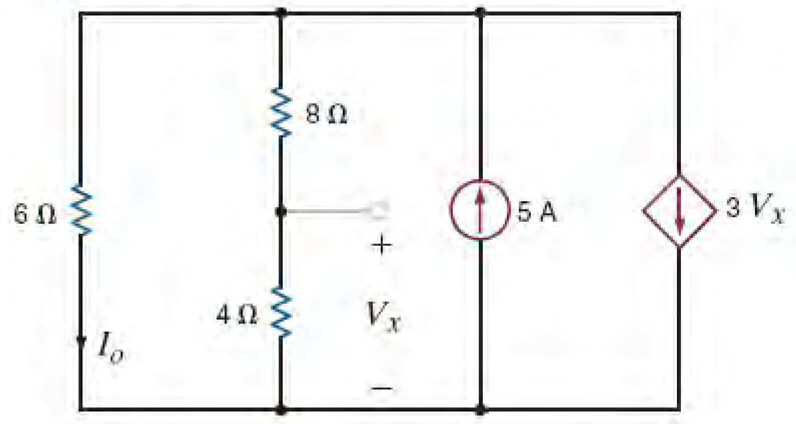



Figure P2.119

## SOLUTION:

KCL:

$$\frac{V_1}{6} + \frac{V_1}{12} + 3V_x = 5$$

$$V_x = \left(\frac{4}{4+8}\right)V_1$$

$$V_x = \frac{V_1}{3}$$

$$\frac{V_1}{6} + \frac{V_1}{12} + 3\left(\frac{V_1}{3}\right) = 5$$

$$2V_1 + V_1 + 12V_1 = 60$$

$$V_1 = 4V$$

$$I_o = \frac{V_1}{6} = \frac{4}{6}$$

$$I_o = \frac{2}{3}\ A$$

**2.120** A typical transistor amplifier is shown in Fig. P2.120. Find the amplifier gain $G$ (i.e., the ratio of the output voltage to the input voltage).

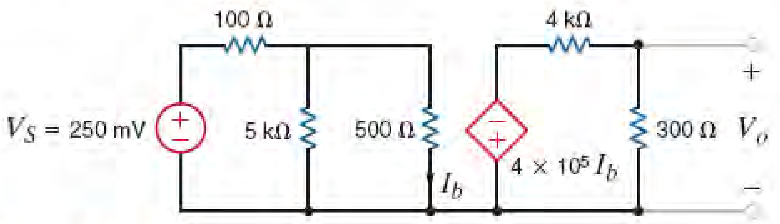
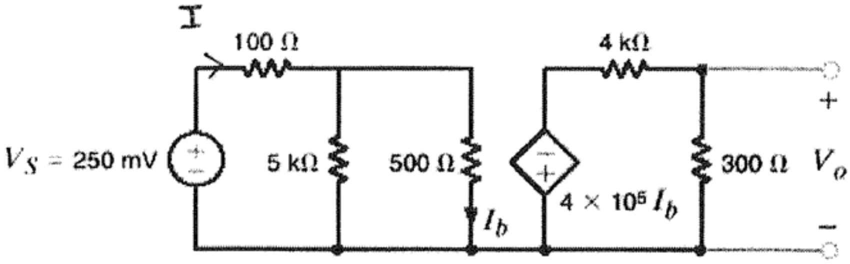



Figure P2.120

## SOLUTION:




$$I = \frac{V_s}{(500 \| 5K) + 100} = \frac{250\,m}{454.55 + 100}$$

$$I = 0.451\,mA$$

$$I_b = \left(\frac{5K}{5K + 500}\right)(0.451m)$$

$$I_b = 0.41\,mAV$$

$$V_o = \left(\frac{300}{4K + 300}\right)(-4 \times 10^5)(0.41\,mA)$$

$$V_o = -11.44\,V$$

$$G = \frac{V_o}{V_s} = \frac{-11.44}{250\,m}$$

$$G = -45.76$$

**2.121** Find the value of k in the network in Fig. P2.121, such that the power supplied by the 6-A source is 108 W.

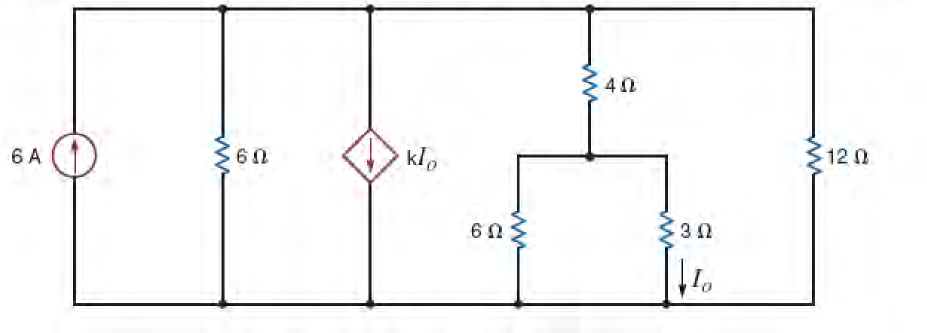
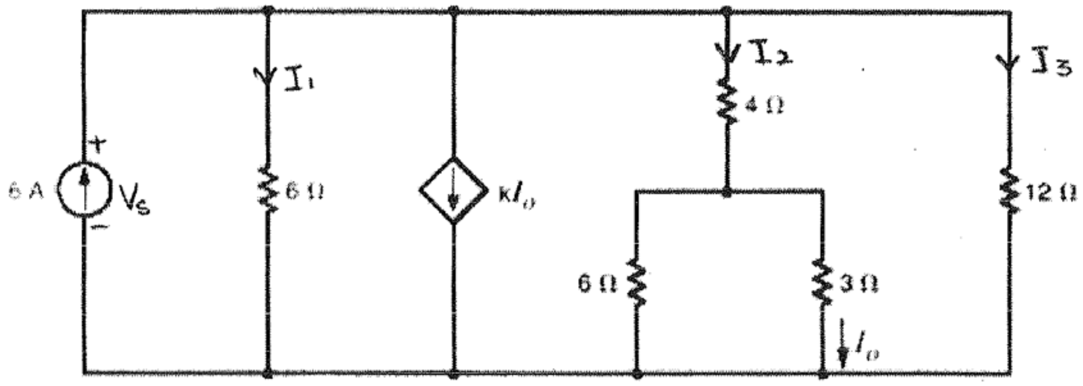



Figure P2.121

## SOLUTION:




$$P_{6A} = V_s I_s$$

$$V_s = \frac{108}{6} = 18V$$

KCL:

$$6 = \frac{V_s}{6} + KI_o + \frac{V_s}{4+(6\|3)} + \frac{V_s}{12}$$

$$6 = \frac{18}{6} + KI_o + 36 + 18$$

$$12KI_o = -18$$

$$KI_o = -1.5V$$

$$I_2 = \frac{V_s}{4+(6\|3)} = \frac{18}{4+2} = 3A$$

$$I_o = \left(\frac{6}{3+6}\right) I_2 = \left(\frac{6}{3+6}\right)(3)$$

$$I_o = 2A$$

$$K = \frac{-1.5}{2}$$

$$K = -0.75$$

**2.122** Find the power supplied by the dependent current source in Fig. P2.122.

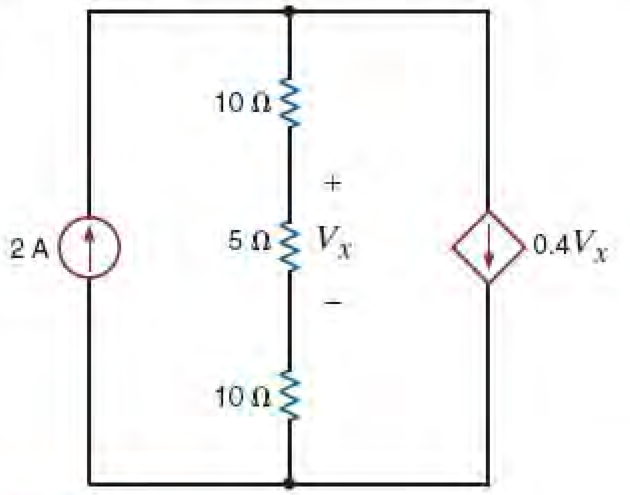
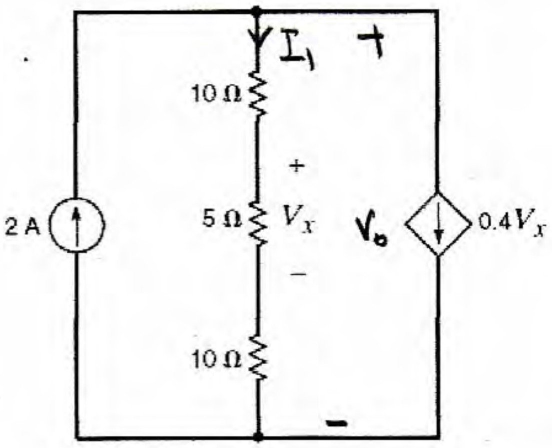



Figure P2.122

## SOLUTION:




$2 = I_1 + 0.4 V_x \qquad V_x = 5 I_1$

$2 = I_1 + (0.4)(5I_1) = I_1 + 2I_1$

$2 = 3I_1 \quad I_1 = 2/3 = 0.667\ A$

$0.4 V_x = 2 - I_1 = 2 - 0.667 = 1.333\ A$

$V_0 = 25 I_1 = 25(0.667) = 16.67\ V$

Pabsorbed by dependent current source :

$P = (16.67)(1.333) = 22.22\ W$

Psupplied by dependent current source :

$P_{sup} = -22.22\ W$

**2.123** If the power absorbed by the 10-V source in Fig. P2.123 is 40 W, calculate $I_S$.

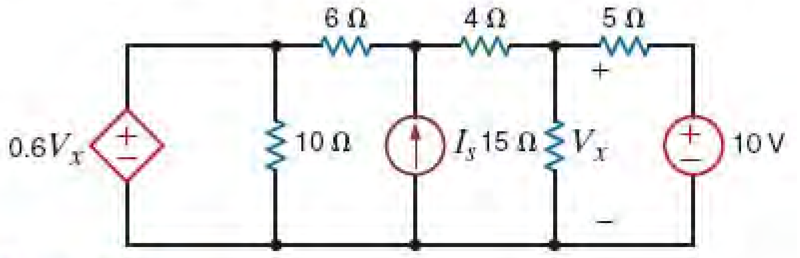
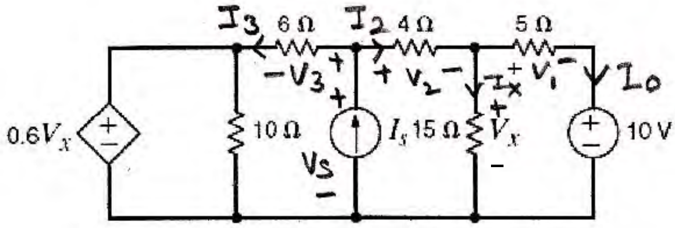



**Figure P2.123**

## SOLUTION:




$$40 = 10I_o \qquad I_o = \frac{40}{10} = 4A$$

$$V_1 = 5I_o = 5(4) = 20\,V$$

$$V_x = V_1 + 10 = 20 + 10 = 30\,V$$

$$I_x = \frac{V_x}{15} = \frac{30}{15} = 2A$$

$$I_2 = I_x + I_o = 2 + 4 = 6A$$

$$V_2 = 4I_2 = (4)(6) = 24\,V$$

$$V_s = V_2 + V_x = 24 + 30 = 54\,V$$

$$V_3 = V_s - 0.6V_x = 54 - (0.6)(30) = 36\,V$$

$$I_3 = \frac{V_3}{6} = \frac{36}{6} = 6A$$

$$I_s = I_3 + I_2 = 6 + 6 = \underline{12A}$$

**2.124** The power supplied by the 2-A current source in Fig. P2.124 is 50 W, calculate $k$.

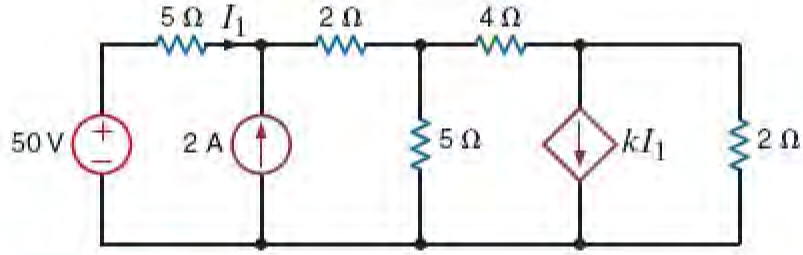
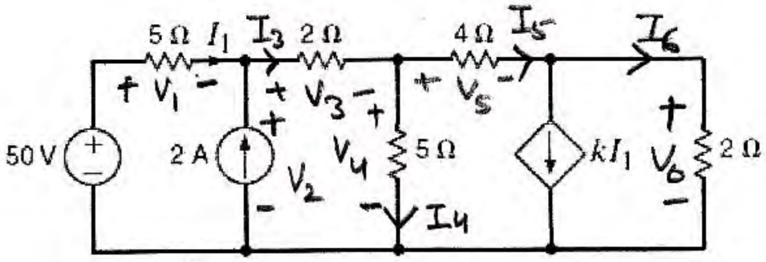



**Figure P2.124**

**SOLUTION:**




$$50 = 2V_2 \qquad V_2 = 25V$$

$$V_1 = 50 - 25 = 25V \qquad I_1 = \frac{V_1}{5} = 5A$$

$$I_3 = I_1 + 2 = 7A$$

$$V_3 = 2I_3 = 14V$$

$$V_4 = -V_3 + V_2 = -14 + 25 = 11V$$

$$I_4 = \frac{V_4}{5} = \frac{11}{5} = 2.2A$$

$$I_5 = I_3 - I_4 = 7 - 2.2 = 4.8A$$

$$V_5 = 5I_5 = 19.2V$$

$$V_6 = -V_5 + V_4 = -19.2 + 11 = -8.2V$$

$$I_6 = \frac{V_6}{2} = \frac{-8.2}{2} = -4.1A$$

$$kI_1 = I_5 - I_6 = 4.8 - (-4.1) = 8.9A$$

$$kI_1 = 8.9$$

$$k = \frac{8.9}{I_1} = \frac{8.9}{5} = \underline{1.78}$$

**2.125** Given the circuit in Fig. P2.125, solve for the value of $k$.

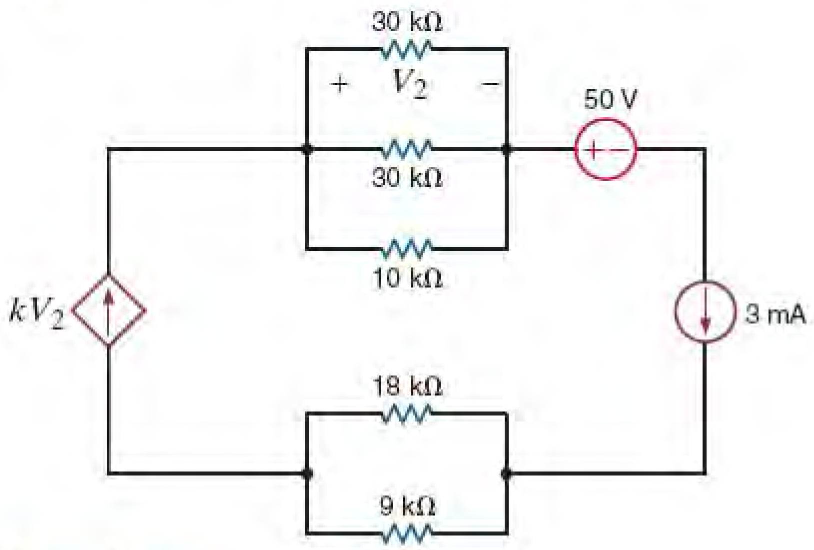
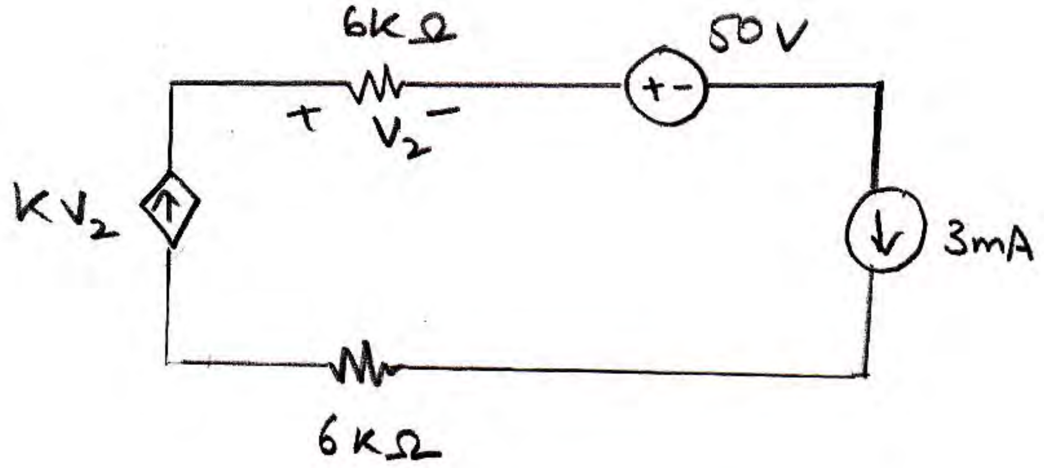



**Figure P2.125**

**SOLUTION:**




$$V_2 = (6k)(3m) = 18V$$

$$kV_2 = 3m$$

$$K = \frac{3 \times 10^{-3}}{18} = \frac{1}{6} \times 10^{-3}$$

$$= 1.667 \times 10^{-4}$$